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Task 3A Report for the Powder River Basin Coal Review Cumulative Air Quality Effects

Executive Summary

The Task 3A Report for the Powder River Basin (PRB) Coal Review describes the projected future cumulative air quality impacts in the PRB study area and at regional assessment areas based on modeling results for future years 2020 and 2030. The analysis focuses on the projected change in impacts resulting from the projected reasonably foreseeable development (RFD) activities in the Wyoming and Montana PRB study areas. Projected future year (2020 and 2030) cumulative impacts for water resources, socioeconomics, and other environmental resources are presented in separate Task 3 Reports. RFD actions are summarized in the Task 2 Report for the PRB Coal Review.

For purposes of the air quality component of the study, the Wyoming PRB study area comprises all of Campbell County, all of Sheridan and Johnson counties outside of the Bighorn National Forest lands to the west of the PRB, and the northern portion of Converse County. It includes all of the area administered by the Bureau of Land Management (BLM) Buffalo Field Office, a portion of the area administered by the BLM Casper Field Office, and a portion of the Thunder Basin National Grasslands, which is administered by the U.S. Forest Service. The Montana portion of the PRB study area comprises portions of Rosebud, Custer, Powder River, Big Horn, and Treasure counties. It encompasses the area administered by the BLM Miles City Field Office and the Billings Field Office. State and private lands also are included in the study area.

ES.1 Technical Approach

The air quality model for the PRB Coal Review was developed for the intended purpose of modeling base year (2008) and projected future year cumulative air quality impacts for this study. The model is not intended for use in evaluating project-specific impacts. The requirements for future project-specific modeling to facilitate site-specific analyses of potential impacts relative to National Ambient Air Quality Standards (NAAQS) and other applicable state standards would be determined in response to state or other regulatory requirements at that time.

The Comprehensive Air Quality Model with Extensions (CAMx) in conjunction with a meteorological model (Weather Research and Forecasting) and an emissions processor system (Sparse Matrix Operator Kernel Emissions [SMOKE]) comprise the CAMx modeling system used for this study. The CAMx modeling system includes three horizontal nested domains developed for the PRB study area: a large domain with coarse 36-kilometer (km) grid resolution, a smaller domain with 12-km grid resolution, and a focused domain with 4-km grid resolution. The 4-km model domain was developed with careful consideration of the PRB study area, Class I areas, and sensitive Class II areas. The model's vertical grid is composed of 38 layers for winter months (December, January, and February) and 34 layers for the remainder of the year to better capture atmospheric properties. The CAMx modeling system and the associated model performance evaluations are discussed in the Task 1A Report (AECOM 2013c).

The CAMx modeling system was used to estimate cumulative air quality impacts on Class I and sensitive Class II areas, as well as sensitive lakes, that would result from base year (2008) emissions (as presented in the Task 1A report) and projected future year (2020 and 2030) emissions. The model was used to address all components of the cumulative air quality impact analysis, including air quality conditions for criteria pollutants, as well as air quality-related values such as changes to visibility, atmospheric deposition, and sensitive lake acid neutralizing capacity (ANC).

Greenhouse gas (GHG) emissions were estimated for future years 2020 and 2030 based on the projected energy-related activities in the Wyoming and Montana PRB study areas as described in the Task 2 Report, plus source-specific emission factors.

ES.2 Modeled Future Year Cumulative Impacts

The future year (2020 and 2030) cumulative air quality impact analysis focuses on the projected change in impacts resulting from the projected RFD activities in the Wyoming and Montana PRB study areas under the upper development scenario. **Table ES.2-1** presents a summary of the modeled base year (2008) and future year (2020 and 2030) cumulative impacts for air quality, visibility, and atmospheric deposition in Class I areas, sensitive Class II areas, and high elevation sensitive lakes.

For regulatory purposes, the Class I and sensitive Class II evaluations are not directly comparable to the air quality permitting requirements because the modeling effort does not segregate increment-consuming sources that would need to be evaluated under the Prevention of Significant Deterioration (PSD) program. The cumulative impact analysis focuses on changes in cumulative impacts versus a comparison to PSD-related evaluations, which would apply to specific sources. The PSD comparisons are for informational purposes only and do not constitute a regulatory PSD increment consumption analysis, which may be required for specific projects by air permitting authorities.

Table ES.2-1 Summary of Modeled Cumulative Air Quality Impacts

Air Quality Component		Base Year 2008	Year 2020	Year 2030
Concentrations	Criteria	Primarily below NAAQS and state AAQS, except CO, ozone, and PM_{10} at five Class I areas and four sensitive Class II areas during wildfire episodes.	Primarily below NAAQS and state AAQS, except CO, ozone, and PM_{10} during wildfire episodes. Generally, the criteria pollutant concentrations projected to be lower than base year (2008) impacts.	Primarily below NAAQS and state AAQS, except CO, ozone, and PM_{10} during wildfire episodes. Generally, the criteria pollutant concentrations projected to be lower than both base year (2008) and future year 2020 impacts.
Visibility	Far-field	The worst visibility values occurred at the Class I Lostwood Wilderness Area (WA) and Class II Fort Laramie National Historic Site, with extinction values of 50.9 Mm^{-1} (16.3 dv).	Projected 20 percent worst visibility values would occur at the Lostwood WA and Medicine Lake WA; however, the extinction values projected to be lower than for the base year (2008).	Projected 20 percent worst visibility values would occur at the Lostwood WA and Medicine Lake WA; however, the extinction values projected to be lower than for both the base year (2008) and future year 2020.
Atmospheric Deposition: Nitrogen[1]	Level of Concern (LOC)	The largest nitrogen deposition in a Class I area occurred at North Absaroka WA (9.89 kilograms nitrogen per hectare per year [kg N/ha/yr]) while the smallest occurred at UL Bend WA (1.43 kg N/ha/yr).	Projected nitrogen deposition values are below 3 kg N/ha/yr except at five Class I and six sensitive Class II areas. Largest nitrogen deposition values projected to occur at the North Absaroka WA and Mount Naomi WA. In all cases, deposition values would be lower than base year 2008.	Projected nitrogen deposition values are below 3 kg N/ha/yr except at five Class I and five sensitive Class II areas. Largest nitrogen deposition values projected to occur at the North Absaroka WA and Mount Naomi WA. In all cases, deposition values would be lower than base year 2008 and future year 2020.

Table ES.2-1 Summary of Modeled Cumulative Air Quality Impacts

Air Quality Component		Base Year 2008	Year 2020	Year 2030
Atmospheric Deposition: Sulfur[1]	LOC	The largest sulfur deposition in a Class I area occurred at Fitzpatrick WA (1.46 kilograms sulfur per hectare per year [kg S/ha/yr]) while the smallest occurred at UL Bend WA (0.23 kg S/ha/yr).	Projected sulfur deposition in all Class I and sensitive Class II areas are below 5 kg S/ha/yr. Values projected to be lower than the sulfur deposition values for base year 2008.	Projected sulfur deposition in all Class I and sensitive Class II areas are below 5 kg S/ha/yr. Values projected to be lower than the sulfur deposition values for base year 2008 and essentially the same as the values for future year 2020.
Atmospheric Deposition: Lake Chemistry[2]	ANC	The largest ANC percent change occurred at Upper Frozen Lake, Bridger WA (304.7 percent) while the smallest percent change occurred at Emerald Lake, Cloud Peak WA (41.5 percent).	Percent change in ANC values projected to decrease at all sensitive lakes relative to base year 2008; however, all exceed the limit of acceptable change.	Percent change in ANC values projected to decrease relative to base year 2008 and future year 2020; however, all exceed the limit of acceptable change.

[1] Nitrogen and sulfur deposition thresholds are published in Baron (2006) and Fox et al. (1989), respectively.

[2] Limit of acceptable change refers to a 10 percent change in ANC for lakes with an ANC of 25 micro-equivalents per liter (µeq/L) or more, or a threshold of 1 µeq/L for lakes with less than 25 µeq/L ANC.

Model-predicted cumulative air quality impacts for the 2020 and 2030 upper development scenarios showed an overall improvement in ambient air quality in both 2020 and 2030 as compared to base year 2008. In general, the modeled cumulative air quality impacts for future years 2020 and 2030 show some exceedences of the NAAQS and state ambient air quality standards (AAQS) for criteria pollutants, especially carbon monoxide (CO), ozone, and particulate matter less than 10 microns in diameter (PM_{10}). These exceedences are attributed to the active wildfire season in 2008. The 2008 wildfire emissions were included in the fire emissions inventory used to model conditions in 2020 and 2030 and are reflected in the model results. In general, modeled pollutant concentrations in areas not influenced by wildfire are below the NAAQS and state AAQS and are similar to or lower than concentrations in 2008.

Besides wildfire, other emissions source sectors contribute to predicted changes in cumulative air quality concentrations between the base year (2008) and each of the future years (2020 and 2030). Source sectors that have the potential to affect air quality conditions in the PRB study area include: mines, conventional oil and gas and coal bed natural gas (CBNG) development, power plants, and mobile sources. Since production from coal mines and some other types of mines is projected to increase by 2020 and 2030 relative to base year 2008, the contribution to particulate matter (PM) concentrations also would likely increase within the PRB study area. Similarly, conventional oil and gas and CBNG development is the third highest source of total organic gases emissions within the 4-km modeling domain, behind biogenic emissions and wildfires. Since conventional oil and gas and CBNG production are projected to decrease by 2020 and 2030 relative to base year 2008, the contribution to ozone nearby and downwind of the PRB study area is likely to decrease. Coal-fired power plants are the highest source of sulfur dioxide (SO_2) emissions within the 4-km domain. SO_2 emissions related to power plants within the PRB study area are projected to increase in 2020 and 2030 as new coal-fired power plants are projected to be permitted and built. As a result, the model-predicted SO_2 impacts increase in 2020 and 2030 when compared to the base year 2008 values for some areas nearby or downwind of the PRB study area. Power plants, mobile sources, conventional oil and gas, and CBNG sources similarly contribute to nitrogen dioxide impacts. Despite these changes in projected development, however,

modeled cumulative air quality conditions indicate improvement between 2008 and 2020 and into 2030. Note that only the upper development scenario was modeled. Model-predicted future levels of ambient air quality, visibility, and deposition between the base year and the future years could be improved if actual coal mine development is less than the upper development scenario.

In both 2020 and 2030, the modeled 20 percent worst visibility values occurred in Lostwood WA and Medicine Lake WA. The modeled 20 percent best visibility values generally occurred in Mount Zirkel WA. Visibility conditions in the Class I and sensitive Class II areas generally show improvement in 2020 and 2030 relative to the base year 2008.

Nitrogen and sulfur deposition resulting from emissions of nitrogen oxide and SO_2 can lead to increasing acidification of sensitive soils and lakes. Based on modeling results, the highest modeled nitrogen deposition would occur at the North Absaroka WA, a Class I area, with nitrogen deposition reaching 9.57 kg N/ha/yr in 2020 and 9.53 kg N/ha/yr in 2030. Projected nitrogen deposition from several Class I and sensitive Class II areas was above the suggested threshold of 3 kg N/ha/yr; however, projected sulfur deposition from all Class I and sensitive Class II areas was below the suggested threshold of 5 kg S/ha/yr. In general, atmospheric deposition of nitrogen and sulfur in the sensitive areas is projected to decrease between base year 2008 and the future years (2020 and 2030). Of the analyzed sensitive lakes, the largest ANC percent change occurred at Upper Frozen Lake in Bridger WA in both 2020 and 2030. While all sensitive lakes considered exceed the limit of acceptable change for ANC, the ANC percent change is projected to improve between base year 2008 and future years 2020 and 2030.

Projected cumulative annual GHG emissions for the lower development scenario are 34,446,877 metric tons per year (tpy) carbon dioxide equivalent (CO_{2eq}) in 2020 and 36,361,575 metric tpy CO_{2eq} in 2030. Projected cumulative annual GHG emissions for the upper development scenario are 38,319,227 metric tpy CO_{2eq} in 2020 and 47,352,653 metric tpy CO_{2eq} in 2030. While currently there are no established thresholds for GHG, the Council on Environmental Quality advises federal agencies to consider an analysis of the direct and indirect GHG emissions from a proposed project if the project would be reasonably anticipated to cause direct emissions of 25,000 metric tpy or more of carbon dioxide equivalent (CO_{2eq}) GHG emissions.

List of Acronyms

µeg/l	micro-equivalents per liter
$\mu g/m^3$	micrograms per cubic meter
AAQS	Ambient Air Quality Standards
ANC	acid neutralizing capacity
AAQS	Ambient Air Quality Standards
AQRVS	air quality-related values
bbls	barrels
BLM	Bureau of Land Management
BNSF	Burlington Northern Santa Fe
CAA	Clean Air Act
CALPUFF	model used to generate long range impact
CAMx	Comprehensive Air Quality Model with Extensions
CBNG	coal bed natural gas
CFR	Code of Federal Regulations
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_{2eq}	carbon dioxide equivalent
dv	deciview
EA	environmental assessment
EIS	Environmental Impact Statement
$eq/m^2/yr$	equivalence per square meter per year
GHG	greenhouse gas
IMPROVE	Interagency Monitoring of Protected Visual Environment
IR	Indian Reservation
kg N/ha/yr	kilograms nitrogen per hectare per year
kg S/ha/yr	kilograms sulfur per hectare per year
km	kilometer
LBA	lease-by-application
LOC	level of concern
MATS	Modeled Attainment Test Software
mb	millibar
Mm^{-1}	Inverse megameter
MOVES	Motor Vehicle Emission Simulator
MMcf	million cubic feet
mmtpy	million tons per year
MPE	Model Performance Evaluation
N_2O	nitrous oxide

NAAQS	National Ambient Air Quality Standards
NEI	National Emissions Inventories
NEPA	National Environmental Policy Act
NF	national forest
NH_3	ammonia
NM	national monument
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NP	national park
NPS	National Park Service
PBL	planetary boundary layer
PM	particulate matter
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
ppb	parts per billion
ppm	parts per million
PRB	Powder River Basin
RFD	reasonably foreseeable development
ROW	right-of-way
RMP	Resource Management Plan
RPO	Regional Planning Organization
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	sulfur dioxide
TOG	total organic gas
tpy	tons per year
UP	Union Pacific
U.S.	United States
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WA	wilderness area
WDEQ	Wyoming Department of Environmental Quality
WRF	Weather Research and Forecasting

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1.0 Introduction

The Powder River Basin (PRB) Coal Review is a regional technical study for assessing the existing conditions and the projected future cumulative impacts associated with energy-related past, present, and reasonably foreseeable development (RFD) in the Wyoming PRB and, for specific resources, the Montana PRB. This study is being conducted by AECOM, Inc., dba AECOM Environment (AECOM) under the direction of the Bureau of Land Management (BLM) High Plains District Office and Wyoming State Office.

1.1 Study Background

The PRB of Wyoming is a major energy development area with diverse resource and environmental values. Energy development has been occurring in the PRB for well over a century. The first coal mine in the basin was developed near Glenrock, in Converse County, in 1883 (Foulke et al. 2002). While coal can be found in several areas of Wyoming, the extensive surface-accessible coal resource is what sets the PRB apart from other energy-producing areas of the state and country. The Wyoming portion of the PRB is the largest coal-producing region in the United States (U.S.); PRB coal is used to generate electricity within and outside of the region. The PRB also has produced large amounts of oil and gas resources. Over the last two decades, this region has experienced nationally significant development of natural gas from coal seams (coal bed natural gas [CBNG]).

Federal coal leasing is a high profile activity as over 90 percent of the PRB's coal is federally owned. The BLM is required to complete a National Environmental Policy Act (NEPA) analysis (environmental impact statement [EIS] or environmental assessment [EA]) for each coal lease-by-application (LBA) as part of the leasing process. In the coal leasing EAs and EISs that have been prepared since the Powder River Regional Coal Team decertified the region in early 1990 (thereby allowing the BLM to use the coal LBA process), cumulative impacts have been addressed in a separate section of the NEPA analyses to highlight the distinction between site-specific and cumulative impacts. With coal leasing continuing into the foreseeable future, and with impacts related to oil and gas development increasing since the late 1990s due to development of CBNG in the PRB, the BLM initiated studies and analyses to provide a consistent basis for evaluation of cumulative impacts in the coal leasing EISs. These studies and analyses included the PRB Coal Development Status Check (BLM 1996); Wyodak EIS (BLM 1999); PRB Oil and Gas EIS (BLM 2003); Montgomery Watson Harza (2003) study of PRB coal demand through 2020; and most recently, the PRB Coal Review.

Initiated in 2003, Phase I of the PRB Coal Review included the identification of current conditions (Task 1 reports); identification of RFD and future coal production scenarios for 2010, 2015, and 2020 (Task 2 report); and predicted future cumulative impacts (Task 3 reports) in the PRB. Phase II of the PRB Coal Review was initiated in January 2010 to update the Phase I analyses. Under Phase II, base year information will be updated through 2008, new RFD and future coal production scenarios will be developed, and projected cumulative impacts will be analyzed for 2020 and 2030.

The PRB Coal Review provides data, models, and projections to facilitate cumulative analyses for BLM's future land use planning efforts and for the cumulative impact sections of future project-specific impact assessments for project development in compliance with NEPA. It should be noted that the PRB Coal Review itself is <u>not</u> a NEPA document. It also is <u>not</u> a policy study, analysis of regulatory actions, or an analysis of the impacts of project-specific development.

This report summarizes Task 3A of the PRB Coal Review, which documents the projected regional cumulative air quality impacts for years 2020 and 2030. The analysis of projected future cumulative impacts is based on the modeling of RFD emissions estimates for projected future sources in the PRB study area in northeastern Wyoming and southeastern Montana (**Figure 1-1**). Impacts are assessed in the PRB study area and at sensitive areas surrounding the region. Assessment areas for the air quality

model were selected as part of the protocol review process (AECOM 2010) to include all regional Class I areas, as identified in the Clean Air Act (CAA) Amendments of 1977, and other environmentally sensitive Class II areas (e.g., national parks [NPs], national monuments [NMs], and wilderness areas [WAs], etc.). The PRB Coal Review Task 3 descriptions for water resources, socioeconomics, and other environmental resources are presented in separate stand-alone reports.

1.2 Objectives

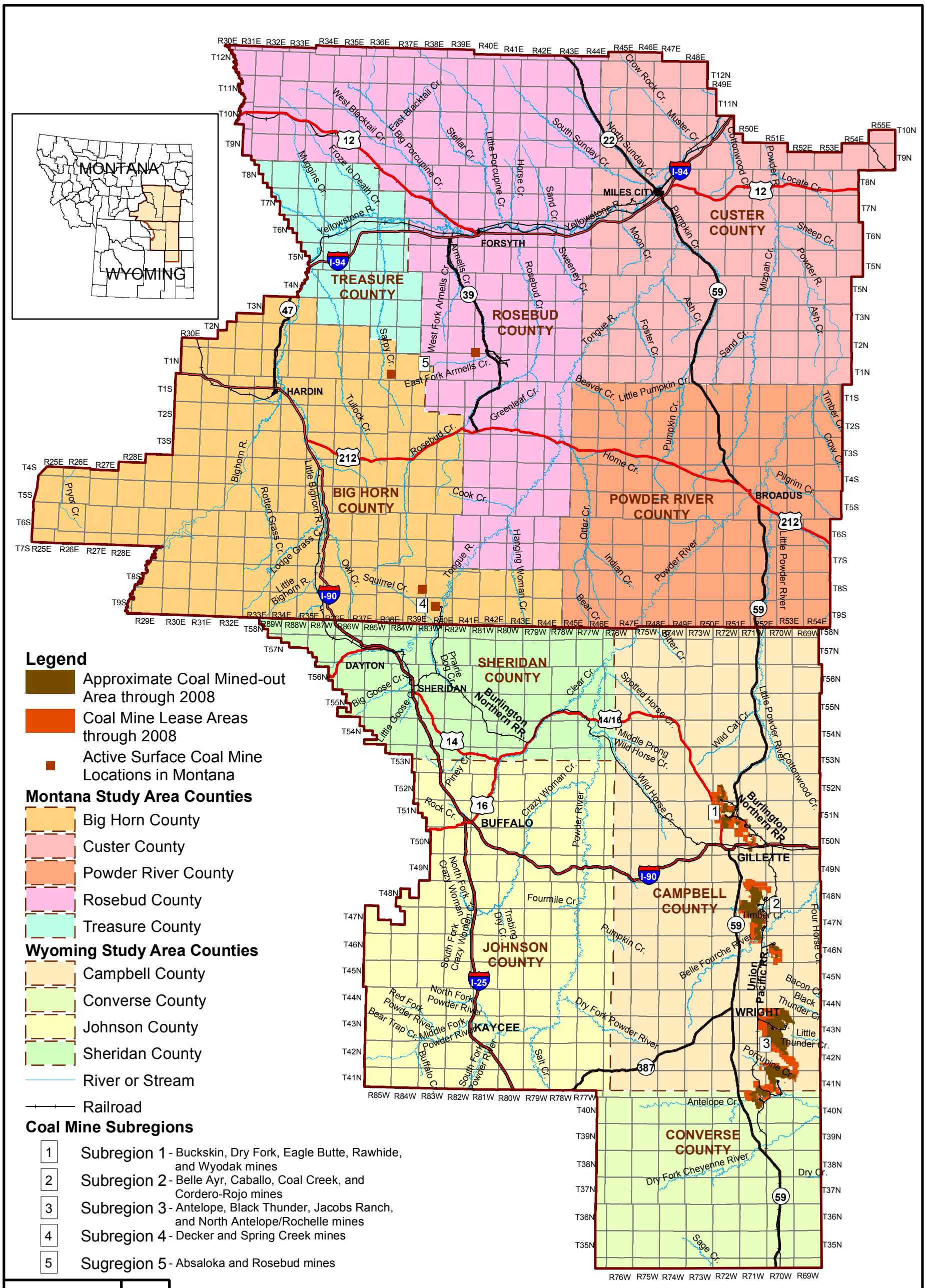
1.2.1 Phase I of the Study

Phase I of the PRB Coal Review was developed as a regional technical study to determine the base year conditions and assess potential future cumulative effects of projected energy-related development activities in the PRB for the years 2010, 2015, and 2020. The Task 1A report (ENSR 2005a) for the PRB Coal Review documented the cumulative air quality impacts during the base year (2002) as obtained from modeling 2002 actual emissions with the CALPUFF model. The base year analysis evaluated impacts on air quality and air quality-related values (AQRVs) both in the near-field and at selected sensitive areas surrounding the region. The analysis specifically looked at impacts of coal and coal-related activities (including power plants) in the PRB of Wyoming and Montana, oil and gas (including conventional oil and gas and CBNG) and related development, and other development-related activities in the Wyoming PRB. Results were provided for both Wyoming and Montana source groups and receptors, including a near-field receptor grid and a set of receptors at the identified sensitive areas.

The Task 2 report (AECOM 2009b; ENSR 2005b) defined the past and present development actions in the Wyoming and Montana PRB study area, as well as the projected RFD scenarios in the study area, for years 2010, 2015, and 2020. The RFD scenarios presented in the Task 2 report provided the basis for the analysis of potential cumulative impacts (Task 3 reports).

Based on the Task 2 RFD scenarios, three separate cumulative air quality impact assessments were performed for future years 2010, 2015, and 2020 as documented in the Task 3A reports (AECOM 2009a; ENSR 2008, 2006). The modeled future cumulative air quality impacts specifically identified changes from the base year (2002) conditions.

The study also included the evaluation of base year conditions (Task 1) and projected cumulative impacts (Task 3) for water resources, socioeconomics, and other environmental resources. The results of these analyses were presented in separate stand-alone reports.



Note: Approximate coal mined-out areas were not available for the Montana mine sites.

Sources: BLM 2010, 2003.

Powder River Basin Coal Review

Figure 1-1

Montana and Wyoming Study Area

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1.2.2 Phase II of the Study

Similar to Phase I, Phase II of the PRB Coal Review is a regional technical study to determine the base year (2008) conditions and assess potential future (2020 and 2030) cumulative effects of projected energy-related development activities in the PRB. Phase II of the study was initiated due to the ongoing energy-related development in the PRB, the elapsed time since initiation of Phase I of the study, and the BLM's need to maintain up-to-date development projections and related projected future cumulative impact analyses for use in the agency LBA EISs and EAs. Under Phase II, the existing and projected future energy-related development activities have been updated (Task 2) based on more recent information, with the air quality, water resources, socioeconomic, and other environmental resources base year analyses (Task 1) and projected cumulative impact analyses (Task 3) correspondingly updated.

Specific to the Phase II air quality component, the Comprehensive Air Quality Model with Extensions (CAMx) was selected in coordination with the BLM in conjunction with a meteorological model (Weather Research and Forecasting [WRF] model) and an emissions processor system (Sparse Matrix Operator Kernel Emissions [SMOKE]) (collectively referred to hereafter as the CAMx modeling system), for use in assessing base year (2008) conditions and projected future cumulative air quality impacts for 2020 and 2030. Base year conditions and projected future cumulative air quality impacts address the assessment areas identified in the Phase II Protocol (AECOM 2010). Modeled cumulative impacts are provided for the Class I and sensitive Class II areas, as well as sensitive lakes, within the 12-kilometer (km) and 4-km grids that cover the PRB study area. The assessment areas closest to the PRB study area are within the 4-km grid to provide enhanced resolution of regional impacts due to ongoing energy-related development in the PRB. As in Phase I, the analysis evaluates air quality conditions for criteria pollutants and AQRVs, such as changes to visibility, atmospheric deposition, and acid neutralizing capacity (ANC) of sensitive lakes. In addition, ozone modeling for base year 2008 and future years (2020 and 2030) has been added to the Phase II air quality analysis based on the elevated ozone concentrations observed in southwestern Wyoming and the lowering of the ambient ozone standard by the U.S. Environmental Protection Agency (USEPA) in May 2008. Also, greenhouse gas (GHG) emissions have been projected for future years 2020 and 2030 for Phase II.

The Task 1A report (AECOM 2013b in progress) documents the modeled base year (2008) regional cumulative air quality impacts in the PRB study area and at regional assessment areas as a result of energy-related development in the Wyoming PRB and Montana PRB study areas. Similarly, this Task 3A report documents the modeled regional cumulative air quality impacts for 2020 and 2030, with the focus on the change in cumulative impacts resulting from the projected Task 2 (AECOM 2011b) RFD scenarios.

Model selection and the methodology for the modeling of base year (2008) conditions and projected future cumulative air quality impacts for 2020 and 2030 are described in the Air Quality Assessment Protocol (AECOM 2010). Other supporting documents for the air quality component of the study include the Meteorological Model Performance Evaluation (MPE) (AECOM 2011a), the Air Quality Model Performance Evaluation (AECOM 2013a), and the Air Quality Technical Support Document (AECOM 2013c in progress).

1.3 Key Issues

The key air quality issues identified for the PRB study include:

- Existing (base year 2008) cumulative nitrogen dioxide (NO_2), particulate matter with an aerodynamic diameter equal or less than 2.5 microns ($PM_{2.5}$), and particulate matter with an aerodynamic diameter equal or less than10 microns (PM_{10}) impacts in the PRB study area and changes in visibility, nitrogen and sulfur deposition, and ANC at surrounding assessment areas.

- Projected future (2020 and 2030) cumulative impacts in the PRB study area and at surrounding assessment areas due to energy-related RFD in the study area, including: coal mining and coal-related activities (including power plants) in the PRB of Wyoming and Montana, oil and gas (including conventional oil and gas and CBNG) and related development, and other development-related activities in Wyoming PRB.

1.4 Agency Outreach, Coordination, and Review

The BLM directed the preparation of this PRB Coal Review. In order to ensure the technical credibility of the data, projections, interpretations, and conclusions of the study and to ensure the study's usefulness for other agencies, the BLM initiated contact with other federal, state, and local agencies early in the Phase I portion of the study. This same approach has been carried forward into Phase II of the study.

As part of this agency outreach and technical oversight, the BLM organized technical advisory groups for each of the key resources (air quality, water resources, and socioeconomics). These groups were composed of agency representatives and stakeholders with technical expertise in the applicable resources. Key participating agencies in the Phase II Air Quality Protocol Group include the BLM, USEPA, U.S. Forest Service (USFS), National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), and Wyoming Department of Environmental Quality (WDEQ).

2.0 Technical Approach

2.1 Overview of Assessment Approach

The air quality model for the PRB Coal Review was developed for the intended purpose of modeling base year (2008) and projected future year cumulative air quality impacts for this study. The model is not intended for use in evaluating project-specific impacts. The requirements for future project-specific modeling to facilitate site-specific analyses of potential impacts relative to National Ambient Air Quality Standards (NAAQS) and other applicable state standards would be determined in response to state or other regulatory requirements at that time.

The CAMx model, in conjunction with a meteorological model (WRF), and an emissions processor system (SMOKE) comprise the CAMx modeling system used for this study. The CAMx modeling system was used to address all components of the cumulative air quality impact analysis, including air quality conditions for criteria pollutants and ozone, as well as AQRVs, such as changes to visibility, atmospheric deposition, and ANC of sensitive lakes. The CAMx modeling system and the associated MPEs are discussed in the Task 1A Report.

The CAMx modeling system was used to estimate potential cumulative air quality impacts on Class I and sensitive Class II areas, as well as sensitive lakes, that would result from base year (2008) emissions (as presented in the Task 1A report) and projected future year (2020 and 2030) emissions (as presented in this report). Model-predicted concentrations of NO_2, sulfur dioxide (SO_2), PM_{10}, $PM_{2.5}$, and ozone, as well as visibility impairment (aerosol light extinction) and nitrogen and sulfur deposition were evaluated at selected assessment areas. The modeled hourly values of applicable pollutant concentrations were processed to compute 3-hour, 8-hour, 24-hour, and annual average concentrations for comparison to appropriate standards and criteria. Visibility estimates were produced for daily intervals, while total sulfur and nitrogen deposition fluxes were computed as cumulative deposition from the entire annual model simulation.

Model results were compared to the following standards and criteria:

- Comparison of the modeled base year (2008) conditions and projected future years (2020 and 2030) cumulative air quality impacts to the applicable state Ambient Air Quality Standards (AAQS) and applicable NAAQS; and
- Evaluation of the modeled change in cumulative air quality conditions and AQRVs resulting from the projected upper development scenarios for 2020 and 2030.

The AQRVs evaluated include visibility and atmospheric deposition. Visibility impacts were evaluated at the assessment areas by using the new Interagency Monitoring of Protected Visual Environment (IMPROVE) equation (Hand and Malm 2006). Atmospheric deposition impacts were assessed for both soils and lakes. Atmospheric deposition to soils was assessed in terms of total terrestrial deposition loading (Fox et al. 1989). Atmospheric deposition impacts were assessed at the levels of concern suggested in Baron (2006) for nitrogen deposition and in Fox et al. (1989) for sulfur deposition. Atmospheric deposition to lakes was assessed in terms of ANC by comparing predicted annual total atmospheric deposition of nitrogen and sulfur to current ANC based on the USFS-recommended prediction methods (USFS 2000).

GHG emissions were estimated for future years 2020 and 2030 based on the projected energy-related activities in the Wyoming and Montana PRB study areas as described in the Task 2 Report, plus source-specific emission factors.

2.2 Model Domains and Assessment Areas

The PRB air quality modeling domains include a coarse domain focused on the continental U.S., with a 36-km horizontal grid resolution and two more refined domains with 12- and 4-km grid resolutions. **Figure 2-1** shows the nested horizontal domains for the CAMx model relative to the horizontal domains of the WRF meteorological model. These domains use the map projection from the Regional Planning Organization (RPO) unified grid. The domains are the same for all modeling performed for the PRB Coal Review. The locations of the Class I and sensitive Class II areas within the 12- and 4-km modeling domains are shown in **Figure 2-2**. Model results for all assessment areas are reported in this document from either the 12-km or the 4-km domain, depending on their location relative to each of these domains.

The model's vertical grid is composed of 34 layers from the surface to the top of the model at 100 millibars (mb) (approximately 14-km above the surface), with thinner (more) layers in the planetary boundary layer (PBL) to better capture the boundary layer characteristics important for air quality modeling. The PBL is the lowest part of the atmosphere where the physical properties of the air are directly influenced by its contact with the ground surface. To better resolve the surface layer for winter months (January, February, and December) when the PBL may be lowest, the first four vertical layers were replaced by eight vertical layers. This resulted in a total of 38 vertical layers for modeling the winter months.

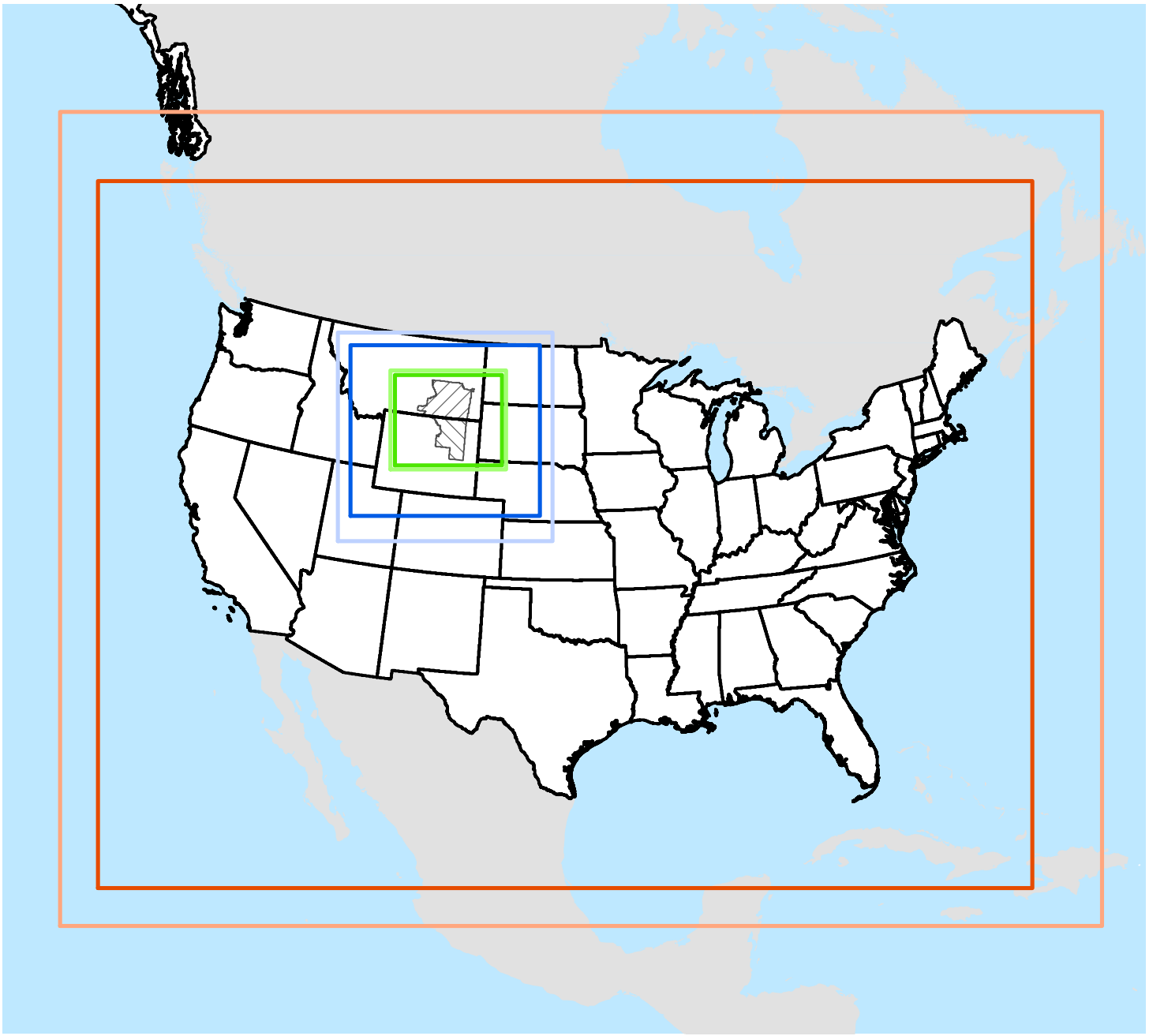
The Class I and sensitive Class II areas were modeled for all air quality metrics (except ANC). The refined 4-km grid was developed with careful consideration of the sensitive areas surrounding the PRB study area. The Class I areas and sensitive Class II areas include the following:

- Badlands NP (Class I, NPS)
- Badlands WA (Class I, NPS)
- Bob Marshall WA (Class I, USFS)
- Bridger WA (Class I, USFS)
- Fitzpatrick WA (Class I, USFS)
- Fort Peck Indian Reservation (IR) (Class I, Fort Peck Tribal Council)
- Gates of the Mountain WA (Class I, USFS)
- Grand Teton NP (Class I, NPS)
- Lostwood WA (Class I, USFWS)
- Medicine Lake WA (Class I, USFWS)
- Mount Zirkel WA (Class I, USFS)
- North Absaroka WA (Class I, USFS)
- Northern Cheyenne IR (Class I, Northern Cheyenne Tribal Council)
- Rawah WA (Class I, USFS)
- Red Rocks Lakes WA (Class I, USFWS)
- Rocky Mountain NP (Class I, NPS)
- Scapegoat WA (Class I, USFS)
- Theodore Roosevelt NP (Class I, NPS)
- UL Bend WA (Class I, USFWS)
- Washakie WA (Class I, USFS)
- Wind Cave NP (Class I, NPS)

- Yellowstone NP (Class I, NPS)
- Absaroka-Beartooth WA (Class II, USFS)
- Agate Fossil Beds NM (Class II, NPS)
- Bighorn Canyon National Recreation Area (Class II, NPS)
- Black Elk WA (Class II, USFS)
- Cloud Peak WA (Class II, USFS)
- Crow IR (Class II, Crow Tribal Council)
- Devils Tower NM (Class II, NPS)
- Dinosaur NM (Class II, NPS)
- Fort Belknap IR (Class II, Fort Belknap Indian Community Council)
- Fort Laramie National Historic Site (Class II, NPS)
- High Uintas WA (Class II, USFS)
- Jewel Cave NM (Class II, NPS)
- Jedediah Smith WA (Class II, USFS)
- Lee Metcalf WA (Class II, USFS)
- Mount Naomi WA (Class II, USFS)
- Mount Rushmore National Memorial (Class II, NPS)
- Popo Agie WA (Class II, USFS)
- Sarvis Creek WA (Class II, USFS)
- Soldier Creek WA (Class II, USFS)
- Teton WA (Class II, USFS)
- Wellsville Mountain WA (Class II, USFS)
- Wind River IR (Class II, Shoshone and Arapaho Joint Tribal Business Council)

Model-predicted annual and total (wet plus dry) deposition fluxes of total nitrogen and total sulfur compounds were used to estimate the ANC (based on total nitrogen and sulfur deposition) at the following sensitive lakes:

- Black Joe Lake, Class I Bridger WA
- Deep Lake, Class I Bridger WA
- Hobbs Lake, Class I Bridger WA
- Upper Frozen Lake, Class I Bridger WA
- Ross Lake, Class I Fitzpatrick WA
- Emerald Lake, Class II Cloud Peak WA
- Florence Lake, Class II Cloud Peak WA
- Lower Saddlebag Lake, Class II Popo Agie WA



Legend

- Wyoming PRB Study Area
- Montana PRB Study Area
- State Boundary
- 36-km PRB WRF Domain
- 12-km PRB WRF Domain
- 4-km PRB WRF Domain
- 36-km PRB CAMx Domain
- 12-km PRB CAMx Domain
- 4-km PRB CAMx Domain

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Powder River Basin Coal Review

Figure 2-1

WRF and CAMx 36-, 12- and 4-km Domains

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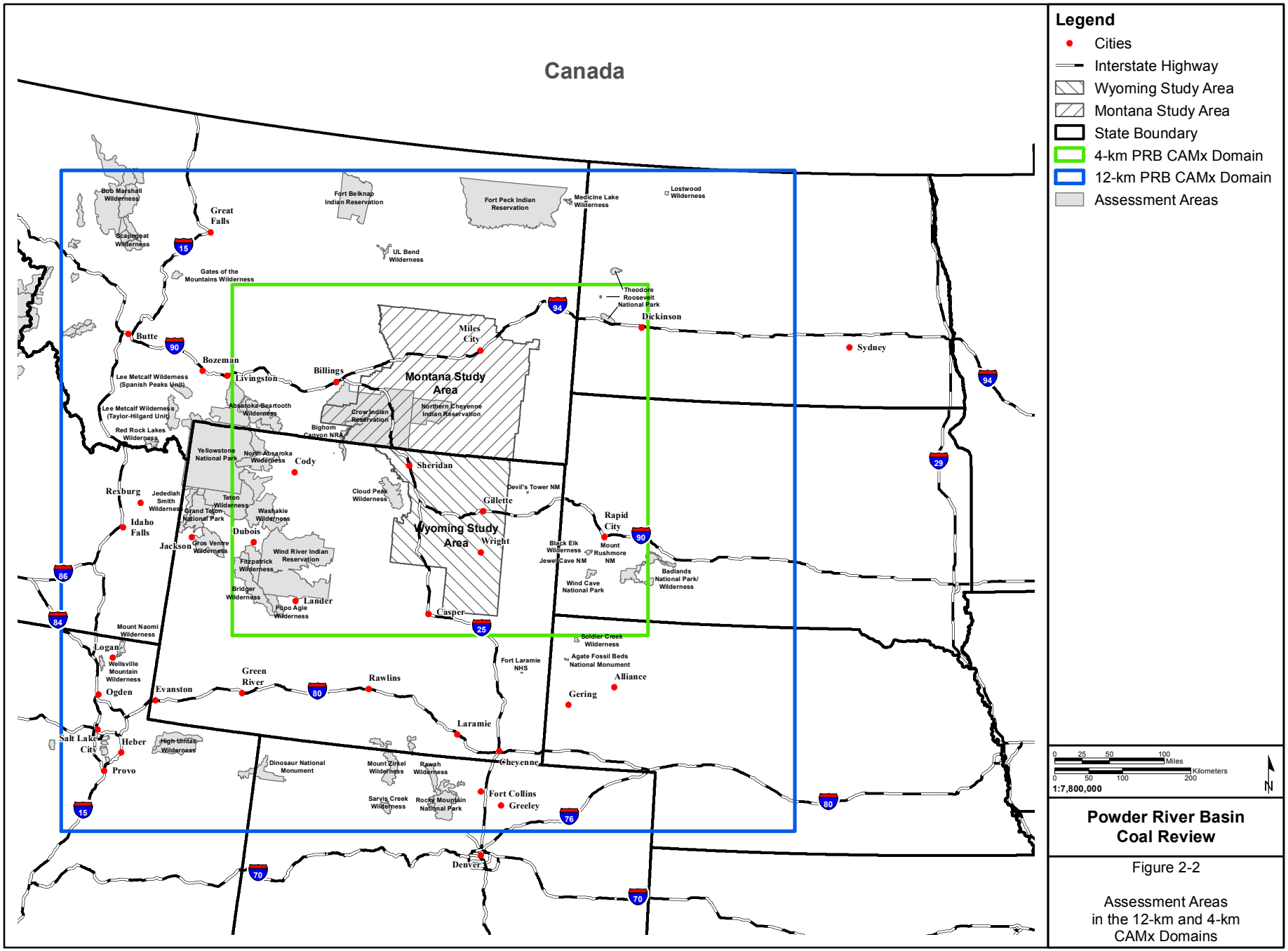

Powder River Basin Coal Review

Figure 2-2

Assessment Areas in the 12-km and 4-km CAMx Domains

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2.3 Modeled Future Years Emissions Inventories

The objective of the air quality component of the PRB Coal Review was to assess the predicted change in air quality and related cumulative impacts based on the projected change in RFD activities in the Wyoming and Montana PRB study areas as identified in the Task 2 Report for the 2020 and 2030 upper production scenarios. The criteria used for generation of the projected RFD emissions included the following:

- Where actual source characteristics (e.g., stack height, temperature, etc.) were provided in the emissions inventories, they were used. Where source characteristics were lacking, representative source characteristics generically were developed for each source type;
- No specific facility boundaries (for ambient air) were developed for individual sites; and
- Emissions were broadly characterized and do not represent actual short-term emission rates.

Based on the upper production scenarios for RFD in the PRB study areas as discussed in the Task 2 Report, the projected emissions from industrial sources within the PRB were calculated for future years 2020 and 2030. The industrial source sectors for which RFD emissions were developed for this study include:

- Coal mines (in both Wyoming and Montana PRB);
- Power plants, including coal- and natural gas-fired plants (in both Wyoming and Montana PRB);
- Railroads (in both Wyoming and Montana PRB);
- Other mines, including bentonite, leonardite, aggregate (sand/gravel/scoria), and uranium (all sources located in Wyoming); and
- Conventional oil and gas and CBNG (all sources located in Wyoming).

In addition to the industrial source sectors listed above, the Task 2 Report includes RFD projections for wind energy, coal technology, transmission line, carbon sequestration, and pipeline projects. Future year RFD emissions were not developed for these source sectors due to the lack of specific information required for emissions estimates. Pipeline emissions were held constant from the base year (2008) emissions inventories.

In addition to the RFD information in the Task 2 Report, the CAMx modeling system requires inclusion of emissions from all source sectors in order to estimate cumulative air quality conditions. Emissions can be grouped into anthropogenic emissions sources (i.e., human activities) and natural sources (e.g., biogenic and wildfire emissions). For source sectors not included in the Task 2 Report, the input data and processing methods to develop future year emissions are documented in the PRB Air Quality Technical Support Document (AECOM 2013b). The modeled base year (2008) emissions inventory for this study is presented in the Task 1A Report.

2.3.1 Meteorological Data

Meteorological data are required to estimate emissions from selected source sectors and simulate air quality conditions using CAMx. Because observed data were not available for the full gridded model domain for this study, a numerical meteorological model (the WRF model) was required to provide these inputs. The meteorological data developed for year 2008 were used to estimate base year (2008) and future year (2020 and 2030) emissions (for a subset of source sectors) as well as cumulative air quality impacts for the corresponding years. The development of these meteorological data is discussed in the Task 1A Report.

2.3.2 RFD Emissions Sources

The upper development scenario RFD emissions were projected based on the energy-related activity data provided in the Task 2 Report. The methodology to develop the RFD emissions is summarized below for each source sector. Modeled RFD emissions values are provided at the end of this section. Detailed information regarding the emissions inventory development and processing methods is provided in the PRB Air Quality Technical Support Document.

Coal Mines

In order to develop future year emissions estimates for coal mines in the PRB study area, two different methods were used depending on whether or not the coal mine operated in 2008. For each coal mine that was operational in 2008, the 2008 base year emissions were scaled to the future years using factors developed based on the projected change in coal mine production and cumulative unreclaimed acreages. Fugitive dust emissions were projected based on the cumulative unreclaimed acreage factors. Emissions from all other coal mine activities were projected using the annual production rate factors. **Table 2-1** shows the range of annual production rate factors and cumulative unreclaimed acreage factors used for each coal mine subregion within the PRB study area (**Figure 1-1**).

Based on the Task 2 Report, five new coal mines are projected to be operational in the Wyoming and Montana PRB study areas before 2020, with an additional coal mine operational by 2030. To estimate future year emissions for these new mines, a method was developed for both fugitive dust emissions and for all other coal mining activities. The projected fugitive dust emissions for new coal mines were estimated based on the relationship between 2008 production and particulate matter (PM) emissions for existing mines. First, a linear regression equation was developed from the existing 2008 coal mine production rates and the calculated PM emission values for each existing mine. The equation then was applied to the projected future production rates for each new coal mine to estimate future fugitive dust PM emissions. To estimate future year emissions from all other activities at new coal mines, an annual average emission rate was developed for each ton of coal production based on 2008 emissions and production levels from existing mines. The annual average emissions rate was multiplied by the projected production for each new coal mine.

Table 2-1 Annual Production Rate and Cumulative Unreclaimed Acreage Factors by Coal Mine Subregion

Coal Mine Subregion	State	Annual Production Rate[1] (million tons per year [mmtpy])			Range of Annual Production Rate Factors[2]		Cumulative Unreclaimed Acreages (acres)[1]			Range of Cumulative Unreclaimed Acreage Factors[2]	
		2008	2020	2030	2008 to 2020	2008 to 2030	2008[3]	2020[4]	2030[4]	2008 to 2020	2008 to 2030
1	Wyoming	75	90	100	1.05 – 1.27	1.1 – 1.46	11,165	13,091	15,024	1.12 – 1.28	1.21 – 1.61
2	Wyoming	103	117	134	0.84 – 1.92	0.84 – 3.06	18,028	22,309	25,601	1.18 – 1.52	1.31 – 2.13
3[5]	Wyoming	265	331	381	0.73 – 1.75	0.83 – 2.14	32,385	37,311	43,964	1.02 – 1.41	1.02 – 1.79
4[5]	Montana	24	34	59	0.17 – 1.25	0.33 – 1.55	10,770	11,544	12,857	1.02 – 1.17	1.06 – 1.29
5[5]	Montana	19	48	78	0.17 – 1.56	0.33 – 1.88	25,025	23,203	26,017	1.07 – 1.15	1.12 – 1.29

[1] Slight differences exist between these data and the Task 2 Report due to rounding.

[2] A range of factors were used to project future emissions due to the variability of individual mine activity within a subregion.

[3] Includes unreclaimed acreages for coal mines that were undergoing final reclamation in 2008.

[4] Includes projected unreclaimed acreages from new coal mines.

[5] Subregions 3 and 4 were projected to have new coal mines operating in 2020, with new mines projected for Subregion 5 in 2020 and 2030. Projection factors for these subregions only apply to mines that operated in 2008. Projected emissions for new mines were calculated as discussed in text.

Power Plants

Table 2-2 identifies the power plants in the PRB study area that were incorporated into the future year inventories. Because the existing power plants are already operating at peak efficiency, their emissions were held constant at the base year (2008) values. Three new coal-fired power plants are projected to come online in the future years based on the anticipated increase in power demand and the high shipping costs for coal transport to outside markets. Projected emissions for the new power plants were generated using linear regression equations for each criteria pollutant by projected plant capacity. Only coal-fired power plants with controlled emissions were used to estimate future emissions from new coal-fired power plants.

Table 2-2 Summary of Power Plants

Power Plant	Fuel Type	State	Permitted or Projected Capacity (megawatt [MW])
Neil Simpson #1	Coal	Wyoming	21.7
Neil Simpson #2	Coal	Wyoming	80
WYGEN 1	Coal	Wyoming	80
WYGEN 2	Coal	Wyoming	90
WYGEN 3[1]	Coal	Wyoming	110
Wyodak I	Coal	Wyoming	330
Arvada	Natural Gas	Wyoming	22.6
Barber Creek	Natural Gas	Wyoming	22.6
Hartzog	Natural Gas	Wyoming	22.6
Dry Fork[1]	Coal	Wyoming	250
Additional power plant[2]	Coal	Wyoming	700
Colstrip	Coal	Montana	2,476
Hardin	Coal	Montana	113
Rosebud	Coal	Montana	120

[1] Projected new power plant operational in 2020 and 2030.

[2] Projected new power plant operational in 2030.

Railroads

Railroad capacity in the PRB study area and associated emissions are projected to increase due to the anticipated demand for PRB coal as a fuel source within and outside of the PRB study area. **Table 2-3** identifies the existing and RFD rail lines in the PRB study area. Similar to the coal mine emissions, two different methods were used to estimate future year railroad emissions depending on whether or not the rail line operated in 2008. Future year emissions for existing rail lines were estimated based on the base year (2008) emissions and the total annual coal production factors shown in **Table 2-4**. The coal production factors shown in **Table 2-4** were developed based on the change in coal production between 2008 and each of the future years (2020 and 2030) for coal mines that operated in 2008 in the PRB study area. The emissions from the new DM&E railroad were estimated using the 2030 railroad emissions for existing railroads and the projected rail line right-of-way (ROW) for DM&E, as presented in

the Task 2 report. Railroad emissions for one RFD spur line and one RFD rail line were not included in the analysis due to the lack of information relative to their potential alignments. It is estimated that railroad emissions for these two lines would represent less than 1 percent of the overall RFD emissions for 2020 and 2030, with the exception of nitrogen oxide (NO_x) which would represent less than 2 percent of the overall RFD emissions for 2020 and 2030.

Table 2-3 Summary of Railroads

Railroad	Owner	State	Emission Calculation Method
Burlington Northern Santa Fe (BNSF) Railroad– serving Decker, Montana[1]	BNSF	Montana	Application of Coal Production Factors
BNSF – serving North Gillette	BNSF	Wyoming	Application of Coal Production Factors
Union Pacific (UP)/BNSF – serving South Gillette and Wright	UP/BNSF	Wyoming	Application of Coal Production Factors
BNSF Mainline and Spur[2]	BNSF	Montana	Application of Coal Production Factors
Youngs Creek Mine Spur Line	BNSF	Montana	Application of Coal Production Factors
DM&E Railroad	Canadian Pacific Railway	Wyoming	Calculated based on length of ROW

[1] Projected capacity upgrade by 2020; no associated change in existing ROW.

[2] Includes projected rail line construction to the proposed Otter Creek Mine.

Table 2-4 Total Annual Coal Production Factors from Existing Coal Mines

Year	Production[1] (mmtpy)	Total Production Rate Factors 2008 to Future Year
2008	488	n/a
2020	563	1.15
2030	651	1.33

[1] Production from RFD coal mines was not included in production totals as discussed above; therefore, totals are different than those presented in the Task 2 report.

Other Mines

Table 2-5 identifies the total annual production from bentonite, leonardite, and aggregate (sand/gravel/scoria) mines in the PRB study area. The associated emissions were calculated based on the production rates and the BLM Buffalo Resource Management Plan (RMP) emissions calculation spreadsheets (BLM 2012a,b,c). The emission for the in situ uranium mines projected to be operational in 2020 were based on the number of in situ wells (total of 4,131) obtained from the Buffalo RMP uranium emissions calculation spreadsheet (BLM 2012c). No production for uranium or bentonite was projected for 2030 due to the uncertainty of additional projects being permitted and developed (AECOM 2011b).

Table 2-5 Total Annual Production from Other Mines

Mine Type	Year	Production (mmtpy)
Bentonite	2008	0.4
	2020	1.4
	2030	0.0
Leonardite	2008	0.1
	2020	0.9
	2030	1.8
Aggregate	2008	5.7
	2020	109.4
	2030	149.1

Sources: AECOM 2011; BLM 2012a,b,c.

Conventional Oil and Gas and CBNG

The 2020 and 2030 oil and gas emissions within the Wyoming PRB study area were developed using different methods depending on the initial source of emissions data. **Table 2-6** presents the projection factors developed for the conventional oil and gas and CBNG well numbers and production for 2020 and 2030 within the Wyoming PRB study area. The methodology used to develop the projection factors is described in detail in the PRB Air Quality Technical Support Document (AECOM 2013b).

For oil and gas point sources, such as compressor stations, the base year 2008 point emissions were projected using factors developed for the oil and gas production in the Wyoming PRB study as shown in **Table 2-6**. The projection factors selected to project the point source emissions depended on the emissions source type. For example, compressor stations were projected using the total gas production factor.

The base year (2008) oil and gas area source emissions within the Wyoming PRB study area were projected to the future years using oil and gas activity as presented in the Task 2 report. Similar to the method used to project the point source oil and gas emissions for base year 2008, the projection factors selected to estimate the future year emissions depended on the emissions source type. For example, drilling and completion emissions from conventional wells were projected using the conventional new wells factor.

Once the future year oil and gas area and point emissions were calculated, on-the-books-controls as identified in the State of Wyoming (WDEQ P-Bact) and USEPA (40 Code of Federal Regulations [CFR] 89.112) oil and gas regulations were applied to more accurately portray future emissions changes due to current regulations.

Table 2-6 Wyoming PRB Study Area Oil and Gas Production Factors

Oil and Gas Activity[1]	2008	2020	2030	Range of 2008 to 2020 Factors	Range of 2008 to 2030 Factors
Conventional Gas Production (million cubic feet [MMcf])	20,089	17,074	9,762	0 – 2.04	0 – 1.08
CBNG Gas Production (MMcf)	530,693	159,908	282,937	0 – 21.53	0 – 138.74
Total Gas Production (MMcf)	**550,782**	**176,982**	**292,699**	**0 – 21.53**	**0 – 138.74**
Condensate Production (barrels [bbls])[2]	4,548,743	1,501,811	411,794	0 – 1.12	0 – 0.30
Oil Well Production (bbls)[2]	6,166,639	3,319,890	1,435,832	0 – 0.72	0 – 0.84
Total Oil Production (bbls)	**10,715,382**	**4,821,701**	**1,847,626**	**0 – 0.66**	**0 – 0.26**
Conventional Wells	3,107	2,783	1,976	0 – 1.25	0 – 0.77
CBNG Wells	19,957	8,646	9,127	0 – 4.77	0 – 15.06
Total Wells	23,064	11,429	11,103	0 – 4.77	0 – 15.06
New Conventional Wells[3]	61	82	84	0 – 17.00	0 – 5.00
New CBNG Wells	1,841	859	434	0 – 10.00	0 – 3.62
New Wells	**1,902**	**941**	**518**	**0 – 17.00**	**0 – 3.62**

[1] Data from Task 2 Report unless noted.

[2] Separation of oil produced from gas wells (i.e., condensate) versus oil wells in 2020 and 2030 is based on the approach developed by AECOM as documented Technical Support Document.

[3] Factors for new conventional wells were not used in the projection of the oil and gas emissions.

2.3.3 Total Future Year Emissions Inventories

To facilitate the modeling of the change in air quality between base year 2008 and each of the future years (2020 and 2030) as a result of the projected RFD activities in the Wyoming and Montana PRB study areas, the future year emissions inventories for all model domains included the projected emissions from the RFD activities as well as other future year emissions source sectors from both anthropogenic and natural sources. The USEPA National Emissions Inventories (NEI) was used to account for changes in future year anthropogenic sources, such as changes in population, air regulations, and economic development. Additional information regarding the development of all emission sources is included in the PRB Air Quality Technical Support Document. The final projected emissions totals for each modeling domain for 2020 and 2030 are presented in **Tables 2-7** and **2-8**, respectively. **Tables 2-9** and **Table 2-10** present the projected annual emissions values for each source sector in the 4-km domain for 2020 and 2030, respectively.

Table 2-7 2020 Annual Emissions by Model Domain

Model Domain	NO_X (tpy)[1]	TOG[2] (tpy)[1]	CO[3] (tpy)[1]	SO_2 (tpy)[1]	PM_{10} (tpy)[1]	$PM_{2.5}$ (tpy)[1]	NH_3[4] (tpy)[1]
36-km	15,288,160	96,146,280	93,791,872	11,515,848	15,585,349	6,307,995	5,508,410
12-km	805,409	5,670,744	4,299,871	351,514	526,256	273,990	277,180
4-km	208,077	1,844,792	2,053,406	90,899	248,344	149,070	58,650

[1] tpy = tons per year.

[2] TOG = total organic gases; includes volatile organic compounds as well as additional organic compounds such as methane [CH_4] and ethane.

[3] CO = carbon monoxide.

[4] NH_3 = ammonia.

Table 2-8 2030 Annual Emissions by Model Domain

Model Domain	NO_X (tpy)	TOG (tpy)	CO (tpy)	SO_2 (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NH_3 (tpy)
36-km	15,301,626	96,076,280	93,823,128	11,521,430	15,596,186	6,309,022	5,508,578
12-km	711,225	5,551,230	4,075,293	355,837	533,924	272,427	276,171
4-km	196,532	1,820,469	2,013,140	95,261	257,379	148,956	58,470

Table 2-9 Projected 2020 Annual Emissions by Sector in the 4-km Domain

Source Sector	NO_X (tpy)	TOG (tpy)	CO (tpy)	SO_2 (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NH_3 (tpy)
Oil and Gas Point	18,747	22,101	11,907	6,018	310	258	6
Oil and Gas Area	14,044	40,810	5,827	798	502	482	0
Mine Point	5,510	136	4,207	198	3,229	645	2
Mine Fugitive Dust	0	0	0	0	20,950	6,707	0
Mine Area	15,713	1,093	7,347	348	2,385	1,157	0
Point	58,137	6,108	18,597	69,245	6,838	4,625	249
Non-Point	13,177	12,857	21,424	4,855	4,191	3,429	69
Mobile	31,163	14,922	162,198	212	1,472	1,406	1,040
Non-road	4,989	7,959	47,575	11	487	487	12
Railroad	11,288	434	1,592	5	305	281	0
Fugitive Dust	0	0	0	0	65,394	10,907	0
Agricultural	0	0	0	0	0	0	31,774
Fire	13,026	383,454	1,563,451	9,209	151,629	128,499	25,499
Biogenic	22,283	1,354,919	209,285	0	0	0	0
Total	**208,077**	**1,844,793**	**2,053,410**	**90,900**	**257,692**	**158,883**	**58,651**

Table 2-10 Projected 2030 Annual Emissions by Sector in the 4-km Domain

Source Sector	NO_X (tpy)	TOG (tpy)	CO (tpy)	SO_2 (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NH_3 (tpy)
Oil and Gas Point	18,288	20,331	11,712	6,382	259	225	5
Oil and Gas Area	10,051	24,815	5,697	511	474	453	0
Mine Point	6,575	153	5,226	243	3,587	683	3
Mine Fugitive Dust	0	0	0	0	26,234	7,294	0
Mine Area	21,408	1,489	10,009	474	3,244	466	0
Point	64,815	6,214	19,444	73,335	7,044	4,695	249
Non-Point	13,177	12,857	21,424	4,855	4,191	3,429	69
Mobile	15,885	7,991	117,622	236	1,253	1,203	859
Non-road	4,994	7,960	47,585	11	488	488	12
Railroad	6,031	287	1,688	6	151	139	0
Fugitive Dust	0	0	0	0	65,394	10,907	0
Agricultural	0	0	0	0	0	0	31,774
Fire	13,026	383,454	1,563,451	9,209	151,629	128,499	25,499
Biogenic	22,283	1,354,919	209,285	0	0	0	0
Total	**196,532**	**1,820,470**	**2,013,143**	**95,263**	**263,947**	**158,483**	**58,469**

The oil and gas point source sector includes compressor stations, associated equipment, and drilling and completion emissions. The oil and gas area source sector includes well pad activities and equipment such as tanks, engines, flaring, venting, and dehydrators for conventional oil and gas and CBNG. The emissions activities associated with mining sources (point and area) include: mine construction, non-road engines that process and transport the mined material, and intra-facility railroad transport. Mine operational fugitive dust (which includes windblown dust associated with coal mines and other mines) was processed under the mine fugitive dust source. The point source sector represents both power plants (coal- and gas-fired) and other sources (e.g., dry cleaners and gas stations) stationary point sources. The non-point source emissions include non-point source airport, boating equipment, and non-PRB locomotive emissions. Mobile emissions were from the Motor Vehicle Emission Simulator (MOVES) model. The non-road source includes all non-road engines except those emissions that are quantified elsewhere (e.g., mining equipment, construction equipment for mining, drill rig engines). The fugitive dust source includes unpaved and paved road dust, commercial and residential construction, agricultural tilling, agricultural planting, and livestock operations. The agricultural source sector contains ammonia (NH_3) emissions from agricultural and anthropogenic activities (e.g., fertilizer application, feedlots, soil). The fire and biogenic emissions were obtained from the SMARTFIRE and MEGAN models, respectively. Additional detail regarding the types of sources included in each emissions category is provided in the PRB Air Quality Technical Support Document.

2.4 Greenhouse Gas Emissions

A GHG emissions inventory was developed for the following source sectors in the Wyoming and Montana PRB study areas for future years 2020 and 2030:

- Coal mining;
- Coal- and natural gas-fired power plants;
- Coal transportation by railroad to the PRB study area boundary; and
- Conventional oil and gas (oil and natural gas) and CBNG development and production.

GHG emissions for these source sectors were developed to provide an estimate of potential GHG emissions associated with future energy-related development. GHG emissions of carbon dioxide (CO_2), CH_4, and nitrous oxide (N_2O) were calculated for each source sector and converted into carbon dioxide equivalents (CO_{2eq}), which is an estimate of the total global warming potential. GHG emissions from coal mining activities, power plants, and coal transportation to the study area boundary were estimated for both an upper and lower production scenario in each future year. Consistent with the PRB Task 2 report, GHG emissions from Wyoming PRB oil, conventional natural gas, and CBNG were estimated for a single production scenario; these emissions apply to both the upper and development scenarios. The methods used to develop GHG emissions varied by source sector; additional information is provided in the PRB Air Quality Technical Support Document (AECOM 2013b). The estimated GHG emissions for future years 2020 and 2030 are presented in Chapter 3.0.

3.0 Predicted Cumulative Air Quality Impacts

The future year (2020 and 2030) cumulative air quality impact analysis focuses on the projected change in impacts (air quality, visibility, atmospheric deposition) resulting from the projected RFD activities in the Wyoming and Montana PRB study areas under the upper development scenario. A separate GHG analysis for future years 2020 and 2030 also is included.

3.1 Air Quality Standards and Thresholds for Comparison

3.1.1 Ambient Air Quality

The modeled concentrations of criteria pollutants at selected assessment areas were compared with applicable health- and welfare-related NAAQS and state AAQS shown in **Table 3-1**. The NAAQS and state AAQS for Montana and Wyoming are established for NO_2, SO_2, PM_{10}, $PM_{2.5}$, ozone, CO, and lead. As discussed in the Task 1A Report, lead is not analyzed as part of this study due to the lack of an identified regional issue for this pollutant in the ambient monitoring data for base year 2008.

For regulatory purposes, the Class I and sensitive Class II evaluations are not directly comparable to the air quality permitting requirements, because the modeling effort does not separate the sources into Prevention of Significant Deterioration (PSD) increment-consuming and non-PSD increment-consuming sources. Therefore, the results cannot be used to develop a pattern of increment consumption for a particular site. The PSD increment level comparisons are for informational purposes only and do not constitute a regulatory PSD increment level consumption analysis, which would be required for evaluating larger projects by air permitting authorities.

Table 3-1 Applicable Ambient Air Quality Standards

Pollutant (units)	Averaging Period	NAAQS[2]	State AAQS[1]		PSD Increments[18]	
			Wyoming[3]	Montana[4]	Class I	Class II
NO_2 (parts per billion [ppb])	1-hour	100[12]	100[12]	300	--	--
	Annual[5]	53	53	50	1.3	13.3
CO (parts per million [ppm])	1-hour[6]	35	35	23	--	--
	8-hour[6]	9	9	9	--	--
SO_2 (ppb)	1-hour	75[13]	75[13]	500[14]	--	--
	3-hour[6]	500	500	--	9.5	195.5
	24-hour[7]	--	--	100	1.9[6]	34.8[6]
	Annual[7]	--	--	20	0.76[5]	7.6[5]
Ozone (ppm)	1-hour[8]	--	--	0.1	--	--
	8-hour[9]	0.075	0.075	--	--	--
$PM_{2.5}$ (micrograms per cubic meter [µg/m^3])	24-hour[10]	35	35	--	2[6]	9[6]
	Annual[5]	12[15]	15	--	1	4
	Annual[5]	15[16]	--	--	1	4
PM_{10} (µg/m^3)	24-hour[11]	150	150	150	8[6]	30[6]
	Annual[5]	--[17]	50	50	4	17

1 Due to the lack of an identified regional issue for lead, it was not analyzed as part of this study.
2 Source: http://www.epa.gov/air/criteria.html#3.
3 Source: http://soswy.state.wy.us/Rules/RULES/8887.pdf.
4 Source: http://www.deq.mt.gov/AirQuality/Planning/AirStandards/AirStandards.pdf.
5 Not to be exceeded.
6 Not to be exceeded more than once per year.
7 Final rule signed June 2, 2010. The 24-hour and annual SO_2 standards from 1971 were revoked in that same rulemaking. However, these standards remain in effect until 1 year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.
8 The USEPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard. The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.
9 To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm. A new 8-hour ozone standard is anticipated to be finalized by the USEPA in 2013.
10 24-hour average of the 98th percentile concentrations (effective December 17, 2006).
11 Not to be exceeded more than once per year on average over 3 years.
12 The 3-year average of the 98th percentile of the daily maximum 1-hour average is not to exceed this standard.
13 The 3-year average of the 99th percentile of the daily maximum 1-hour average is not to exceed this standard.
14 Not to be exceeded more than 18 times in any 12 consecutive months.
15 Primary standard, annual mean, averaged over 3 years.
16 Secondary standard, annual mean, averaged over 3 years.
17 The annual PM_{10} NAAQS of 50 µg/m^3 was revoked by the USEPA on September 21, 2006; see Federal Register, volume 71, number 200, 10/17/06.
18 Source: 40 Code of Federal Regulations Part 52, Section 21, as amended by the Final Rule in Federal Register, volume 70, number 59582 (10/12/05) and Federal Register, volume 75, number 64863 (10/20/10).

3.1.2 Visibility

Under the CAA, visibility has been established as a critical resource for identified Class I areas. There are no federal regulations for visibility impairment at Class II locations. Estimated visibility impacts at the Class I areas and sensitive Class II areas are presented in terms of the 20 percent best days and 20 percent worst days. Visibility impacts are expressed in terms of deciviews (dv), a measure for describing perceived changes in visibility. The deciview values were calculated from model-predicted concentrations of chemical compounds that scatter or absorb light using the IMPROVE equation (Hand and Malm 2006) to estimate light extinction (in inverse megameters [Mm^{-1}]) and converted into dv's. The model-predicted light extinction in the future years is shown relative to the base year (2008) light extinction (presented in the Task 1A Report). There are no current thresholds established for evaluating cumulative visibility impacts.

3.1.3 Atmospheric Deposition

3.1.3.1 Deposition

Model-predicted annual deposition fluxes of total nitrogen and sulfur compounds to terrestrial ecosystems were calculated for each Class I and sensitive Class II assessment area in terms of kilograms of nitrogen or sulfur per hectare per year (kg N/ha/yr and kg S/ha/yr, respectively). The model-predicted annual deposition was compared with the thresholds of 1.5 kg N/ha/yr for nitrogen deposition (Baron 2006) and 5 kg S/ha/yr for sulfur deposition (Fox et al. 1989) as discussed in Section 2.1. The nitrogen deposition level of concern is based on the critical loads suggested in Baron (2006). The sulfur deposition level of concern is based on the green line thresholds in Fox et al. (1989) for the Bob Marshall WA in Montana and the Bridger WA in Wyoming that are thought to be acceptable until more protective thresholds are established.

3.1.3.2 Sensitive Lake Acid Neutralizing Capacity

Model-predicted annual deposition fluxes of total nitrogen and sulfur compounds to aquatic ecosystems were calculated for each sensitive lake in terms of ANC. Potential changes in ANC were estimated following the procedure developed by the USFS Rocky Mountain Region (USFS 2000). The predicted changes in ANC were compared with the levels of acceptable change. The level of acceptable change in ANC for lakes with background ANC values greater than 25 micro equivalents per liter [µeq/L] is 10 percent, while for lakes with background ANC values equal to or less than 25 µeq/L, the level of acceptable change is no more than 1 µeq/L.

3.2 Summary of Cumulative Impacts

The modeled future year (2020 and 2030) cumulative air quality impacts at the assessment areas were evaluated as a comparison to the current modeled air quality conditions for base year 2008. The assessment areas for this study include the Class I and sensitive Class II areas and, for ANC, sensitive lakes located within the 12-km model domain. These assessment areas are identified in Section 2.2 and shown in **Figure 2-2**. A summary of maximum modeled impacts for the key components of the analysis (air quality, visibility, and atmospheric deposition) for base year 2008 and projected years 2020 and 2030 are presented in **Table 3-2**. It should be noted that the summer of 2008 was a very active fire season, and various wildfires reflected in the modeled emissions inventory for 2008 had an impact on criteria pollutants at different times and assessment areas.

Table 3-2 Summary of Modeled Cumulative Air Quality Impacts

Air Quality Component		Base Year 2008	Year 2020	Year 2030
Concentrations	Criteria	Primarily below NAAQS and state AAQS, except CO, ozone, and PM_{10} at five Class I areas and four sensitive Class II areas during wildfire episodes.	Primarily below NAAQS and state AAQS, except CO, ozone, and PM_{10} during wildfire episodes. Generally, the criteria pollutant concentrations projected to be lower than base year (2008) impacts.	Primarily below NAAQS and state AAQS, except CO, ozone, and PM_{10} during wildfire episodes. Generally, the criteria pollutant concentrations projected to be lower than both base year (2008) and future year 2020 impacts.
Visibility	Far-field	The worst visibility values occurred at the Class I Lostwood WA and Class II Fort Laramie National Historic Site, with extinction values of 50.9 Mm^{-1} (16.3 dv).	Projected 20 percent worst visibility values would occur at the Lostwood WA and Medicine Lake WA; however, the extinction values projected to be lower than for the base year (2008).	Projected 20 percent worst visibility values would occur at the Lostwood WA and Medicine Lake WA; however, the extinction values projected to be lower than for both the base year (2008) and future year 2020.
Atmospheric Deposition: Nitrogen[1]	Level of Concern (LOC)	The largest nitrogen deposition in a Class I area occurred at North Absaroka WA (9.89 kg N/ha/yr) while the smallest occurred at UL Bend WA (1.43 kg N/ha/yr).	Projected nitrogen deposition values are below 3 kg N/ha/yr except at five Class I and six sensitive Class II areas. Largest nitrogen deposition values projected to occur at the North Absaroka WA and Mount Naomi WA. In all cases, deposition values would be lower than base year 2008.	Projected nitrogen deposition values are below 3 kg N/ha/yr except at five Class I and five sensitive Class II areas. Largest nitrogen deposition values projected to occur at the North Absaroka WA and Mount Naomi WA. In all cases, deposition values would be lower than base year 2008 and future year 2020.
Atmospheric Deposition: Sulfur[1]	LOC	The largest sulfur deposition in a Class I area occurred at Fitzpatrick WA (1.46 kg S/ha/yr) while the smallest occurred at UL Bend WA (0.23 kg S/ha/yr).	Projected sulfur deposition in all Class I and sensitive Class II areas are below 5 kg S/ha/yr. Values projected to be lower than the sulfur deposition values for base year 2008.	Projected sulfur deposition in all Class I and sensitive Class II areas are below 5 kg S/ha/yr. Values projected to be lower than the sulfur deposition values for base year 2008 and essentially the same as the values for future year 2020.

Table 3-2 Summary of Modeled Cumulative Air Quality Impacts

Air Quality Component		Base Year 2008	Year 2020	Year 2030
Atmospheric Deposition: Lake Chemistry[2]	ANC	The largest ANC percent change occurred at Upper Frozen Lake, Bridger WA (304.7 percent) while the smallest percent change occurred at Emerald Lake, Cloud Peak WA (41.5 percent).	Percent change in ANC values projected to decrease at all sensitive lakes relative to base year 2008; however, all exceed the limit of acceptable change.	Percent change in ANC values projected to decrease relative to base year 2008 and future year 2020; however, all exceed the limit of acceptable change.

[1] Nitrogen and sulfur deposition thresholds are published in Baron (2006) and Fox et al. (1989), respectively.

[2] Limit of acceptable change refers to a 10 percent change in ANC for lakes with an ANC of 25 µeq/L or more, or a threshold of 1 µeq/L for lakes with less than 25 µeq/L ANC.

3.3 Cumulative Impacts on Ambient Air Quality

Cumulative impacts on ambient air quality were analyzed for the 2020 and 2030 upper development scenarios at all Class I and sensitive Class II assessment areas. Predicted future year cumulative impacts were compared with the base year (2008) impacts to provide an understanding of the potential changes to current air quality conditions. The ambient air quality impacts presented in this report are consistent with the definition of the NAAQS and state AAQS shown in **Table 3-1**.

Future year results are limited by the model's ability to reproduce observed concentrations. Based on the Air Quality MPE (AECOM 2013a) which evaluated the modeled base year 2008 results in relation to reported monitoring data, the model tended to under-predict concentrations of several gas-phase criteria pollutants (i.e., NO_2, CO, and SO_2). This indicates that the future year concentrations likely would be higher than the modeled values presented in this report. The model tended to over-predict ozone concentrations in the summer (when observed values typically are highest near the PRB study area), indicating that future year ozone concentrations likely would be lower than the modeled values presented in this report. Note that results reported for monitored locations using the Modeled Attainment Test Software (MATS) tool account for the model bias by incorporating the monitored concentrations into the estimated future concentrations. Therefore, the future year ozone concentrations reported for monitored locations are considered to be more accurate than the concentrations reported for assessment areas without monitors. The modeled concentrations of particle-phase criteria pollutants (i.e., $PM_{2.5}$ and PM_{10}) tended to be fairly accurate in rural areas. As a result, the model performance for most species of PM are within USEPA-established criteria when compared with monitors in rural areas (AECOM 2013a). However, the model tended to under-predicted PM_{10} concentrations within the PRB study area (AECOM 2013c). This indicates that the future year $PM_{2.5}$ and PM_{10} concentrations for assessment areas outside of the PRB study area likely would be similar to the modeled values presented in this report; however, future year PM_{10} concentrations for assessment areas within the PRB study area likely would be higher than the modeled values.

3.3.1 2020 Upper Development Scenario

3.3.1.1 Class I and Sensitive Class II Assessment Areas

Table 3-3 presents the modeled cumulative air quality impacts for Class I and sensitive Class II assessment areas for year 2020. Based on the modeling results, all NO_2 values are projected to be well below the NAAQS and state AAQS. While model-predicted CO concentrations exceed the ambient standards at five Class I areas and four Class II areas, these exceedences also were noted for base year 2008 as indicated in the Task 1A Report (AECOM 2013c). For all Class I and sensitive Class II

areas, modeled concentrations for all pollutants remain unchanged or tend to decrease in 2020 relative to the base year (2008). In one Class I area (Rocky Mountain NP) and four Class II areas (Dinosaur NM, both sections of the High Uintas WA, and Popo Agie WA) that exceeded the NAAQS for ozone in 2008, the modeled ozone concentration for 2020 decreased enough to drop these concentrations below the NAAQS.

As discussed in that the Task 1A report, model-predicted CO exceedences of the ambient standards most likely are due to the active wildfire season in 2008. The 2008 wildfire emissions also were included in the fire emissions inventory used to model conditions in 2020 and 2030 and are reflected in the model results (e.g., North Absaroka WA shows exceedences in 2020 for SO_2, ozone, $PM_{2.5}$, and PM_{10} in addition to CO). In general, modeled ozone concentrations in areas not influenced by wildfire are below the NAAQS and state AAQS, with the exception of one Class I area (Washakie WA) and four Class II areas (Bighorn Canyon National Recreation Area, Mount Naomi WA, Wellsville Mountain WA, and Wind River IR). Likewise, modeled PM_{10} concentrations in areas not influenced by wildfires are below the NAAQS and state AAQS, with the exception of one Class I area (Washakie WA) and two Class II areas (Bighorn Canyon National Recreation Area and Wind River IR). All $PM_{2.5}$ concentrations in areas not influenced by wildfire are below the NAAQS and state AAQS. It should be noted that for every assessment area that exceeded the CO NAAQS, the percent change between 2020 and 2008 for both the 1- and 8-hour NAAQS was zero. This supports the relationship between modeled exceedences and the fire emissions inventory.

Figures showing the modeled 2020 concentrations during periods with elevated levels of air quality impacts are shown in **Figures 3-1** through **3-3**. Note that no figures are displayed for NO_2 as all modeled 2020 values are projected to be well below the NAAQS and state AAQS.

The model-predicted change in air quality between base year 2008 and year 2020 are shown relative to PSD increments in **Table 3-4**. There are no PSD increments established for CO or ozone; therefore, they are not included in this table. Note that no model-predicted concentration changes exceeded PSD increments.

3.3.1.2 Cumulative Ozone Impacts at Monitored Locations

Table 3-5 provides the MATS 8-hour ozone design values for base year 2008 and future year 2020 at available monitoring sites in the 12-km domain. As shown, the base year 2008 design value for 10 of the 38 monitors exceed the ozone NAAQS. Based on the model-predicted ozone changes between 2020 and base year 2008, the 2020 design values show no monitors exceed the NAAQS. The largest ozone design value projected for 2020 (0.073 ppm) is at site 490350003 located near Salt Lake City, Utah, far from the PRB study area. Two monitors are located in the PRB study area, both within Campbell County, Wyoming. The 8-hour ozone design values for 2020 indicate values in the PRB study area may range from 0.061 to 0.066 ppm. Downwind from the PRB study area, a monitor located near Wind Cave NP shows that 2020 ozone design values could reach 0.061 ppm. In all three cases, the 2020 ozone design values are well below the NAAQS.

Table 3-3 Modeled 2020 Concentrations of Criteria Pollutants

Assessment Area	NO_2 (ppb)		CO (ppb)		SO_2 (ppb)		Ozone (ppm)	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)
	1-hour	Annual	1-hour	8-hour	1-hour	3-hour	8-hour	24-hour	Annual	24-hour
Class I Areas										
Badlands NP	1	0	0	0	0	0	0.064	9	3.7	20
Badlands WA	1	0	0	0	0	0	0.064	9	3.7	20
Bob Marshall WA, Flathead National Forest (NF)[1]	1	0	3	2	0	0	0.062	12	3.5	100
Bob Marshall WA, Lolo NF[1]	0	0	1	0	0	0	0.062	10	3.3	20
Bob Marshall WA, Lewis and Clark NF[1]	1	0	1	0	0	0	0.061	11	3.4	20
Bridger WA[2]	1	0	**117**	**86**	1	300	**0.148**	17	6.0	**3,740**
Fitzpatrick WA[2]	1	0	**48**	**29**	1	100	**0.188**	17	4.2	**940**
Fort Peck IR	1	0	3	2	0	0	0.067	10	4.3	100
Gates of the Mountains WA	1	0	1	1	0	0	0.063	12	3.7	30
Grand Teton NP	1	0	3	2	1	0	0.068	14	4.1	90
Lostwood WA	1	0	0	0	1	0	0.057	10	4.6	20
Medicine Lake WA	1	0	0	0	0	0	0.059	10	4.5	20
Mount Zirkel WA	1	0	1	0	0	0	0.069	7	2.7	20
North Absaroka WA[2]	4	1	**639**	**363**	7	**1,300**	**0.269**	**103**	***15.0***	**11,000**
Northern Cheyenne IR	1	0	2	2	1	0	0.067	13	4.0	100
Rawah WA	1	0	1	1	0	0	0.067	7	2.7	30
Red Rock Lakes WA[2]	3	1	**108**	**57**	6	200	**0.179**	**104**	**12.8**	**2,710**
Rocky Mountain NP	2	0	1	1	0	0	0.073	7	2.8	30
Scapegoat WA	0	0	1	1	0	0	0.063	11	3.4	30
Theodore Roosevelt NP	3	1	1	0	0	0	0.056	9	3.9	10
UL Bend WA	1	0	3	2	0	0	0.065	11	4.1	80
Washakie WA	0	0	9	4	0	0	0.079	11	3.2	160
Wind Cave NP	1	0	1	1	0	0	0.067	9	3.5	30
Yellowstone NP[2]	1	0	**61**	**40**	1	200	**0.103**	21	5.2	**1,570**
Class II Areas										
Absaroka-Beartooth WA, Gallatin NF[1,2]	1	0	**71**	**23**	1	100	**0.081**	19	4.3	**680**
Absaroka-Beartooth WA, Custer NF[1,2]	0	0	**137**	**85**	1	300	**0.154**	22	7.3	**3,840**
Agate Fossil Beds NM	1	0	0	0	0	0	0.065	8	3.6	20

Table 3-3 Modeled 2020 Concentrations of Criteria Pollutants

Assessment Area	NO_2 (ppb)		CO (ppb)		SO_2 (ppb)		Ozone (ppm)	$PM_{2.5}$ ($\mu g/m^3$)		PM_{10} ($\mu g/m^3$)
	1-hour	Annual	1-hour	8-hour	1-hour	3-hour	8-hour	24-hour	Annual	24-hour
Bighorn Canyon National Recreation Area	1	0	7	5	1	0	**0.089**	21	4.3	**250**
Black Elk WA	1	0	0	0	0	0	0.067	8	3.3	20
Cloud Peak WA[2]	0	0	**45**	**38**	1	100	0.074	15	3.5	**1,380**
Crow IR[2]	1	0	**43**	**28**	1	100	**0.096**	18	4.2	**1,140**
Devil's Tower NM	2	0	0	0	0	0	0.067	9	3.6	20
Dinosaur NM	1	0	3	3	0	0	0.072	8	3.2	110
Fort Belknap IR	1	0	1	0	0	0	0.065	10	4.0	20
Fort Laramie National Historic Site	2	1	0	0	0	0	0.065	8	3.7	20
High Uintas WA, Ashley NF[1]	1	0	0	0	0	0	0.070	7	2.6	30
High Uintas WA, Wasatch NF[1]	1	0	1	1	0	0	0.071	7	2.7	30
Jewel Cave NM	1	0	1	1	0	0	0.066	8	3.3	20
Jedediah Smith WA	1	0	2	1	1	0	0.067	12	4.1	60
Lee Metcalf WA, Taylor-Hilgard Unit[1,2]	1	0	15	7	2	0	**0.118**	30	5.2	**290**
Lee Metcalf WA, Monument Mountains Unit[1,2]	1	0	13	7	1	0	**0.095**	27	5.4	**290**
Lee Metcalf WA, Spanish Peaks Unit[1,2]	1	0	9	6	1	0	**0.082**	20	4.4	**250**
Mount Naomi WA	8	2	1	1	0	0	**0.077**	11	4.9	30
Mount Rushmore National Memorial	1	0	0	0	0	0	0.066	8	3.2	20
Popo Agie WA	1	0	8	3	1	0	0.067	10	2.9	80
Sarvis Creek WA	1	0	1	1	0	0	0.067	7	2.9	30
Soldier Creek WA	1	0	0	0	0	0	0.064	8	3.4	20
Teton WA	1	0	4	2	1	0	0.068	12	3.7	70
Wellsville Mountain WA	8	2	1	1	0	0	**0.080**	13	5.9	40
Wind River IR	1	0	14	5	1	0	**0.133**	11	3.3	**180**

Note: Model-predicted concentrations that exceed the NAAQS are shown in **bold** text. For $PM_{2.5}$, ***bold and italic*** text indicates a modeled impact above the secondary $PM_{2.5}$ NAAQS.

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

[2] Maximum impacts of CO, ozone, and PM can be attributed to wildfires in 2008 that were included in the fire emissions inventory used to model future year conditions.

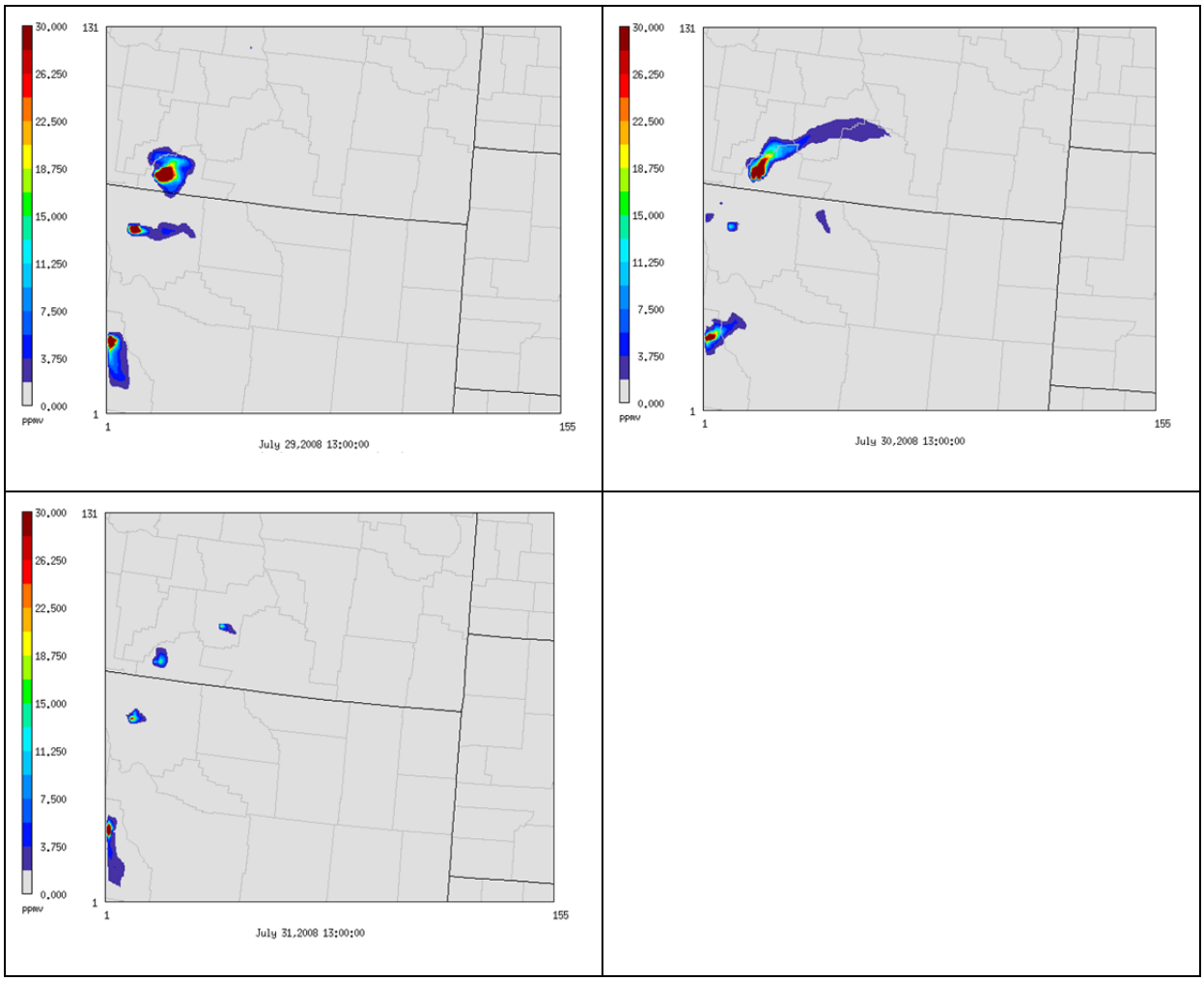

Figure 3-1 Year 2020 Model-predicted Hourly Average CO from July 29 through July 31

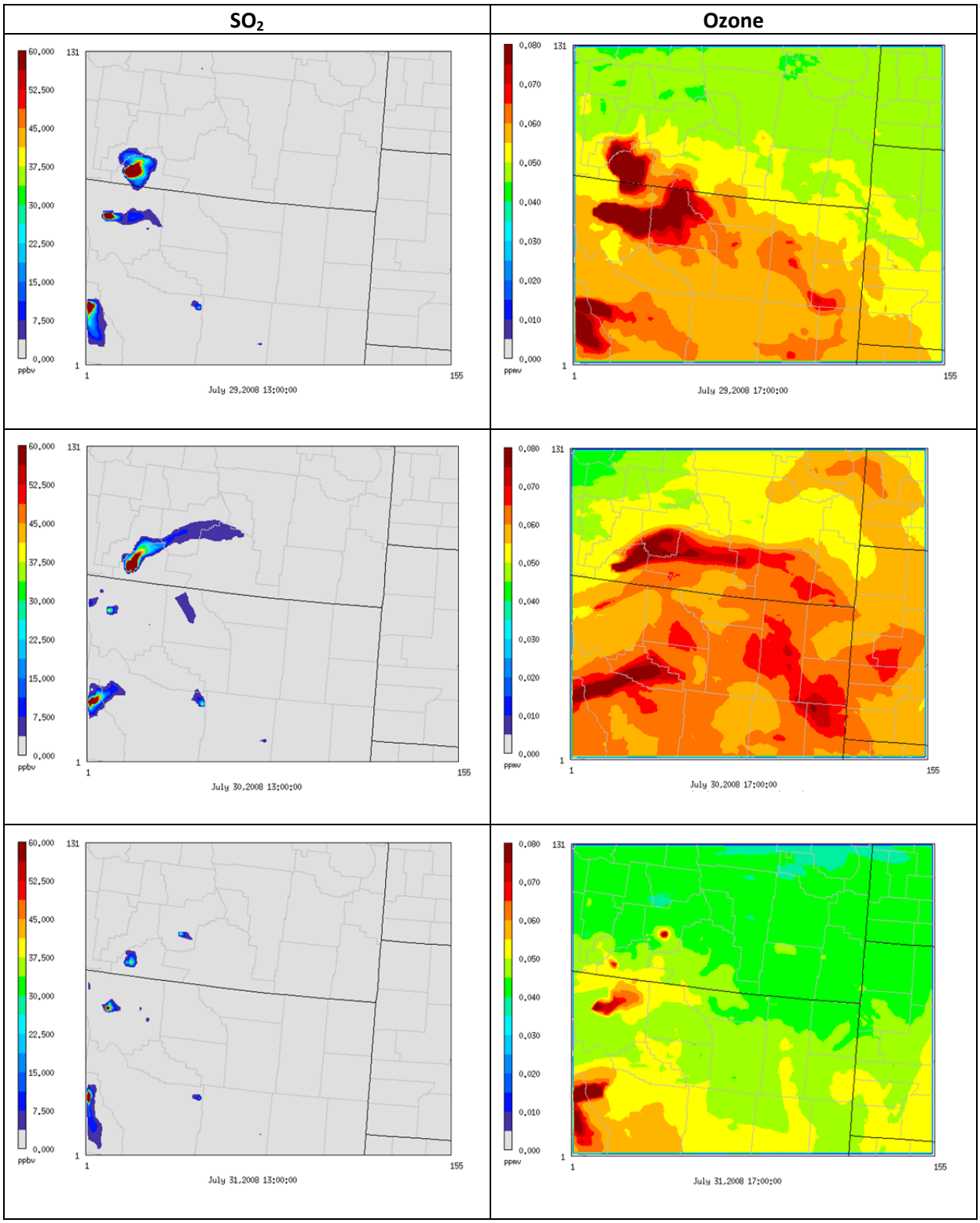

Figure 3-2 Year 2020 Model-predicted Hourly Average SO_2 and Ozone from July 29 through July 31

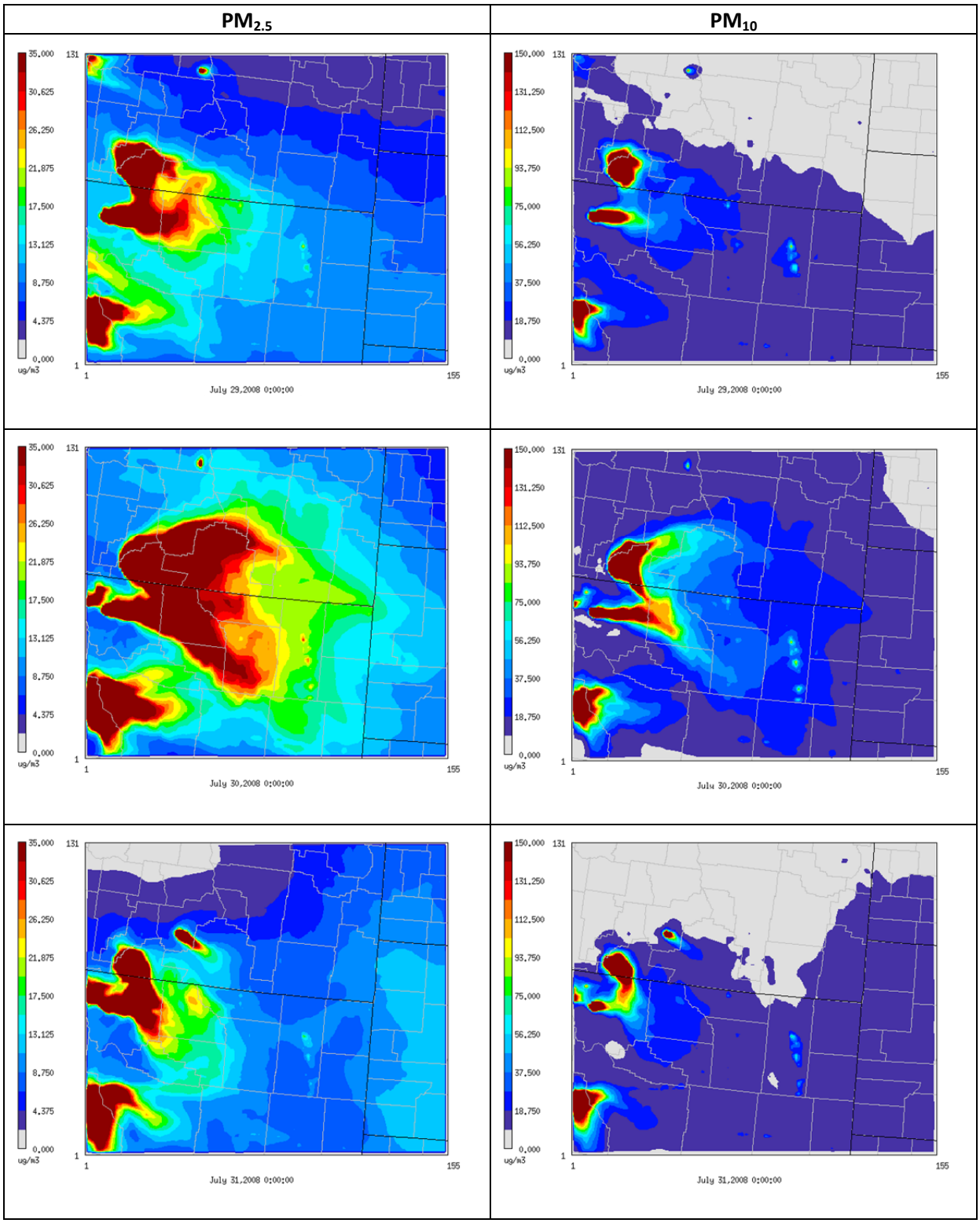

Figure 3-3 Year 2020 Model-predicted Daily Average $PM_{2.5}$ and PM_{10} from July 29 through July 31

Table 3-4 Changes in Modeled Concentrations for Class I and Sensitive Class II Assessment Areas from 2008 to 2020

Assessment Area	NO_2 (ppb)	SO_2 (ppb)	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)
	Annual	3-hour	24-hour	Annual	24-hour
Class I Areas					
Badlands NP	-0.1	0.0	-0.5	-0.2	0.0
Badlands WA	-0.1	0.0	-0.5	-0.2	0.0
Bob Marshall WA, Flathead NF[1]	-0.1	0.0	-0.2	-0.1	-0.1
Bob Marshall WA, Lolo NF[1]	-0.1	0.0	-0.3	-0.1	-0.3
Bob Marshall WA, Lewis and Clark NF[1]	-0.1	0.0	-0.2	-0.1	0.0
Bridger WA	-0.1	0.0	0.0	-0.2	-0.6
Fitzpatrick WA	0.0	0.0	-0.2	-0.1	-0.7
Fort Peck IR	-0.2	0.0	-0.4	-0.2	-0.3
Gates of the Mountains WA	-0.2	0.0	-0.2	-0.1	-0.4
Grand Teton NP	-0.2	0.0	-0.1	-0.3	-1.3
Lostwood WA	-0.2	0.0	-0.5	-0.2	-0.6
Medicine Lake WA	-0.2	0.1	-0.5	-0.2	0.0
Mount Zirkel WA	-0.1	0.0	-0.4	-0.2	-0.1
North Absaroka WA	-0.1	0.0	-0.2	-0.2	-0.6
Northern Cheyenne IR	-0.1	0.0	-0.1	-0.1	-0.1
Rawah WA	-0.1	-0.1	-0.3	-0.2	-0.2
Red Rock Lakes WA	-0.1	0.0	-1.4	-0.3	-1.2
Rocky Mountain NP	-0.4	0.0	-0.4	-0.2	-1.2
Scapegoat WA	-0.1	0.0	-0.3	-0.1	-0.3
Theodore Roosevelt NP	0.0	-0.1	-0.5	-0.2	-0.4
UL Bend WA	0.0	0.0	-0.1	-0.1	0.0
Washakie WA	-0.1	0.0	-0.1	-0.1	-0.3
Wind Cave NP	-0.1	0.0	-0.1	-0.1	-0.1
Yellowstone NP	-0.1	0.0	-0.1	-0.3	-0.3
Class II Areas					
Absaroka-Beartooth WA, Gallatin NF[1]	-0.1	0.0	-0.1	-0.2	-0.1
Absaroka-Beartooth WA, Custer NF[1]	-0.1	0.0	-0.1	-0.1	-0.3
Agate Fossil Beds NM	-0.2	-0.1	-0.3	-0.3	-0.1
Bighorn Canyon National Recreation Area	-0.1	0.1	-0.1	-0.1	-0.4
Black Elk WA	-0.2	-0.1	-0.1	-0.1	0.4
Cloud Peak WA	0.0	0.0	-0.1	-0.1	-0.4
Crow IR	-0.1	0.4	-0.1	-0.1	0.0
Devil's Tower NM	-0.1	0.1	-0.1	-0.1	0.7
Dinosaur NM	-0.1	0.0	-0.3	-0.5	-0.4
Fort Belknap IR	-0.1	0.0	-0.1	-0.1	0.0
Fort Laramie National Historic Site	-0.8	0.0	-0.5	-0.4	-0.5
High Uintas WA, Ashley NF[1]	-0.2	-0.3	-0.3	-0.3	-0.2

Table 3-4 Changes in Modeled Concentrations for Class I and Sensitive Class II Assessment Areas from 2008 to 2020

Assessment Area	NO_2 (ppb)	SO_2 (ppb)	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)
	Annual	3-hour	24-hour	Annual	24-hour
High Uintas WA, Wasatch NF[1]	-0.2	0.0	-0.3	-0.3	-0.2
Jewel Cave NM	-0.1	0.0	-0.1	-0.1	-0.3
Jedediah Smith WA	-0.2	0.0	-0.2	-0.3	-0.2
Lee Metcalf WA, Taylor-Hilgard Unit[1]	-0.1	0.0	-0.1	-0.2	-0.8
Lee Metcalf WA, Monument Mountains Unit[1]	-0.1	0.0	-0.1	-0.3	-0.8
Lee Metcalf WA, Spanish Peaks Unit[1]	-0.1	0.0	-0.6	-0.2	-0.1
Mount Naomi WA	-1.7	0.0	-1.4	-0.9	-1.9
Mount Rushmore National Memorial	-0.2	0.0	-0.1	-0.1	0.4
Popo Agie WA	0.0	0.4	-0.3	-0.2	-0.4
Sarvis Creek WA	-0.2	0.0	-0.3	-0.2	-0.5
Soldier Creek WA	-0.2	-0.1	-0.1	-0.2	-0.1
Teton WA	-0.1	0.0	0.0	-0.2	-0.1
Wellsville Mountain WA	-2.3	-0.3	-3.6	-1.5	-1.7
Wind River IR	-0.1	0.4	-0.1	-0.1	-0.7

Note: No model-predicted concentration changes exceeded PSD increments.

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

Table 3-5 MATS 8-hour Ozone Design Values for Base Year 2008 and Future Year 2020 at Monitoring Sites

Monitoring Site	Monitoring Site ID	Latitude (degrees)	Longitude (degrees)	Ozone Design Value (ppm)	
				2008	2020
Badlands NP, Jackson County, South Dakota	460711001	43.7469	-101.9411	0.068	0.061
Bismarck Residential, Burleigh County, North Dakota	380150003	46.8254	-100.7682	0.057	0.052
Boulder, Sublette County, Wyoming	560350099	42.7190	-109.7530	**0.079**	0.072
Brigham City, Box Elder County, Utah	490030003	41.4928	-112.0181	0.075	0.063
Daniel South, Sublette County, Wyoming	560350100	42.7907	-110.0551	0.069	0.063
Dunn Center, Dunn County, North Dakota	380250003	47.3132	-102.5273	0.057	0.053
Elementary School, Meade County, South Dakota	460930001	44.1556	-103.3158	0.056	0.051
Fargo, Mercer County, North Dakota	380570004	47.2986	-101.7669	0.060	0.057
Fort Collins, Larimer County, Colorado	80691004	40.5775	-105.0789	0.070	0.061
Fort Collins West, Larimer County, Colorado	80690011	40.5925	-105.1411	**0.080**	0.069
Hannover, Oliver County, North Dakota	380650002	47.1858	-101.4281	0.059	0.055
Herriman, Salt Lake County, Utah	490353008	40.5179	-112.0231	**0.080**	0.070
Highland, Utah County, Utah	490495008	40.4303	-111.8039	0.075	0.068
Jonah, Sublette County, Wyoming	560350098	42.4365	-109.6959	0.070	0.063
Lakepoint, Salt Lake County, Utah	490352004	40.7364	-112.2103	**0.079**	0.068
Logan, Cache County, Utah	490050004	41.7311	-111.8375	0.070	0.059
Lostwood WA, Burke County, North Dakota	380130004	48.6419	-102.4018	0.058	0.055
Murphy Ridge, Uinta County, Wyoming	560410101	41.3731	-111.0424	0.064	0.054
North Provo, Utah County, Utah	490490002	40.2536	-111.6631	0.073	0.064
North Salt Lake City, Davis County, Utah	490110004	40.9030	-111.8845	**0.080**	0.071
Ogden, Weber County, Utah	490571003	41.3037	-111.9871	**0.079**	0.068
Overlook, McKenzie County, North Dakota	380530002	47.5812	-103.2995	0.062	0.058
Portage, Box Elder County, Utah	490037001	41.9460	-112.2332	0.074	0.062
Rocky Mountain NP, Larimer County, Colorado	80690007	40.2772	-105.5450	0.075	0.065
Salt Lake City, Salt Lake County, Utah	490353006	40.7364	-111.8722	**0.078**	0.068
Salt Lake City, Salt Lake County, Utah	490350003	40.6467	-111.8497	**0.080**	0.073
South Campbell County, Campbell County, Wyoming	560050456	44.1470	-105.5300	0.066	0.061
Spanish Fork, Utah County, Utah	490495010	40.1364	-111.6597	0.075	0.065
Theodore Roosevelt NP, Billings County, North Dakota	380070002	46.8943	-103.3785	0.062	0.057

Table 3-5 MATS 8-hour Ozone Design Values for Base Year 2008 and Future Year 2020 at Monitoring Sites

Monitoring Site	Monitoring Site ID	Latitude (degrees)	Longitude (degrees)	Ozone Design Value (ppm)	
				2008	2020
Thunder Basin, Campbell County, Wyoming	560050123	44.6522	-105.2903	0.070	0.066
Tooele, Tooele County, Utah	490450003	40.5434	-112.2988	0.075	0.066
Wamsutter, Sweetwater County, Wyoming	560370200	41.6775	-108.0246	0.064	0.054
Washington Terrace, Weber County, Utah	490570007	41.1797	-111.9831	**0.081**	0.071
Weld County Tower, Weld County, Colorado	81230009	40.3864	-104.7374	0.075	0.067
West Valley City, Salt Lake County, Utah	490353007	40.7044	-111.9686	**0.081**	0.070
Wind Cave NP, Custer County, South Dakota	460330132	43.5578	-103.4839	0.066	0.061
Yellowstone NP, Teton County, Wyoming	560391011	44.5653	-110.4000	0.064	0.060
Yellowstone NP, Yellowstone County, Montana	301110086	45.9426	-108.3510	0.059	0.054

Note: **Bold** text indicates design values that exceed the 8-hour ozone NAAQS.

3.3.2 2030 Upper Development Scenario

3.3.2.1 Class I and Sensitive Class II Assessment Areas

Table 3-6 presents the modeled cumulative air quality impacts for Class I and sensitive Class II assessment areas for year 2030. Similar to 2020, all NO_2 values in 2030 are projected to be well below the NAAQS and state AAQS. While model-predicted CO concentrations exceed the ambient standards at five of the Class I areas and four of the Class II areas, these exceedences also were noted for base year 2008 as indicated in the Task 1A Report (AECOM 2013c). For all Class I and sensitive Class II areas, modeled concentrations for all pollutants remain unchanged or tend to decrease in 2030 relative to the base year (2008). Similar to 2020, the modeled concentrations for ozone in one Class I area (Rocky Mountain NP) and six Class II areas (Dinosaur NM, both sections of the High Uintas WA, Mount Naomi WA, Popo Agie WA, and Wellsville Mountain WA) that exceeded the NAAQS in 2008, decreased enough in 2030 to drop these concentrations below the NAAQS.

As discussed in the Task 1A report, model-predicted CO exceedences are likely due to impacts from wildfires in 2008, which also were included in the fire emissions inventory used to model conditions in 2020 and 2030 and are reflected in the model results (e.g., North Absaroka WA shows exceedences in 2030 for SO_2, ozone, $PM_{2.5}$, and PM_{10} in addition to CO). In general, ozone and PM_{10} concentrations in areas not influenced by wildfire are below the NAAQS and state AAQS, with the exception of one Class I area (Washakie WA) and two Class II areas (Bighorn Canyon National Recreation Area and Wind River IR). All model-predicted $PM_{2.5}$ concentrations in areas not influenced by wildfire are below the NAAQS and state AAQS. It should be noted that for every assessment area that exceeded the CO NAAQS, the percent change between 2020 and 2008 for both the 1- and 8-hour NAAQS was zero. This supports the relationship between modeled exceedences and the fire emissions inventory.

Figures showing the modeled 2030 concentrations during periods with elevated levels of air quality impacts are shown in **Figures 3-4** through **3-6**.

The model-predicted change in air quality between base year 2008 and year 2030 are shown relative to PSD increments in **Table 3-7**. There are no PSD increments established for CO or ozone; therefore,

they are not included in this table. Note that no model-predicted concentration changes exceeded PSD increments.

3.3.2.2 Cumulative Ozone Impacts at Monitored Locations

Table 3-8 provides the MATS 8-hour ozone design values for base year 2008 and future year 2030 at available monitoring sites in the 12-km domain. As shown, the base year 2008 design value for 10 of the 38 monitors exceed the ozone NAAQS. Based on the model-predicted ozone changes between 2030 and base year 2008, the 2030 design values show no monitors exceed the NAAQS. The largest ozone design value projected for 2030 (0.071 ppm) is at site 560350099 located in Sublette County, Wyoming, far from the PRB study area. Two monitors are located in the PRB study area, both within Campbell County, Wyoming. The 2030 design values for these two locations indicate peak ozone concentrations in the PRB study area may range from 0.060 to 0.065 ppm. Downwind from the PRB study area, a monitor located near Wind Cave NP shows that 2030 ozone design values could reach 0.060 ppm. In all three cases, the 2030 ozone design values are well below the NAAQS.

Table 3-6 Modeled 2030 Concentrations of Criteria Pollutants

Assessment Areas	NO_2 (ppb)		CO(ppm)		SO_2(ppb)		Ozone (ppm)	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)
	1-hour	Annual	1-hour	8-hour	1-hour	3-hour	8-hour	24-hour	Annual	24-hour
Class I Areas										
Badlands NP	1	0	0	0	0	0	0.063	9	3.6	20
Badlands WA	1	0	0	0	0	0	0.063	9	3.7	20
Bob Marshall WA, Flathead NF[1]	0	0	3	2	0	0	0.062	12	3.5	100
Bob Marshall WA, Lolo NF[1]	0	0	1	0	0	0	0.062	10	3.3	20
Bob Marshall WA, Lewis and Clark NF[1]	1	0	1	0	0	0	0.061	11	3.4	20
Bridger WA[2]	1	0	**117**	**86**	1	300	**0.148**	17	6.0	**3,740**
Fitzpatrick WA[2]	0	0	**48**	**29**	1	100	**0.188**	17	4.2	**940**
Fort Peck IR	1	0	3	2	0	0	0.066	10	4.3	100
Gates of the Mountains WA	1	0	1	1	0	0	0.062	11	3.7	30
Grand Teton NP	1	0	3	2	1	0	0.067	14	4.1	90
Lostwood WA	1	0	0	0	1	0	0.057	10	4.6	20
Medicine Lake WA	1	0	0	0	0	0	0.058	10	4.4	20
Mount Zirkel WA	1	0	1	0	0	0	0.068	7	2.7	20
North Absaroka WA[2]	3	1	**639**	**363**	7	**1,300**	**0.269**	**103**	***15.0***	**11,000**
Northern Cheyenne IR	1	0	2	2	1	0	0.066	13	3.9	100
Rawah WA	0	0	1	1	0	0	0.066	7	2.7	30
Red Rock Lakes WA[2]	3	0	**108**	**57**	6	200	**0.178**	**104**	**12.7**	**2,710**
Rocky Mountain NP	1	0	1	1	0	0	0.069	7	2.7	30
Scapegoat WA	0	0	1	1	0	0	0.063	11	3.4	30
Theodore Roosevelt NP	3	1	1	0	0	0	0.055	9	3.9	10
UL Bend WA	1	0	3	2	0	0	0.064	11	4.1	80
Washakie WA	0	0	9	4	0	0	**0.079**	11	3.2	**160**
Wind Cave NP	1	0	1	1	0	0	0.067	9	3.4	30
Yellowstone NP[2]	1	0	**61**	**40**	1	200	**0.103**	21	5.2	**1,570**
Class II Areas										
Absaroka-Beartooth WA, Gallatin NF[1, 2]	1	0	**71**	**23**	1	100	**0.081**	19	4.2	**680**
Absaroka-Beartooth WA, Custer NF[1, 2]	0	0	**137**	**85**	1	300	**0.153**	22	7.3	**3,840**
Agate Fossil Beds NM	1	0	0	0	0	0	0.064	8	3.5	20
Bighorn Canyon National Recreation	1	0	7	5	1	0	**0.089**	20	4.3	**250**

Table 3-6 Modeled 2030 Concentrations of Criteria Pollutants

Assessment Areas	NO_2 (ppb)		CO(ppm)		SO_2(ppb)		Ozone (ppm)	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)
	1-hour	Annual	1-hour	8-hour	1-hour	3-hour	8-hour	24-hour	Annual	24-hour
Area										
Black Elk WA	1	0	0	0	0	0	0.066	8	3.3	20
Cloud Peak WA[2]	0	0	**45**	**38**	1	100	0.074	15	3.5	**1,380**
Crow IR[2]	1	0	**43**	**28**	1	100	**0.096**	18	4.2	**1,140**
Devil's Tower NM	1	0	0	0	0	0	0.067	9	3.6	20
Dinosaur NM	1	0	3	3	0	0	0.068	8	3.1	110
Fort Belknap IR	1	0	1	0	0	0	0.064	10	4.0	20
Fort Laramie National Historic Site	2	1	0	0	0	0	0.064	8	3.6	20
High Uintas WA, Ashley NF[1]	1	0	0	0	0	0	0.067	7	2.6	30
High Uintas WA, Wasatch NF[1]	1	0	1	1	0	0	0.067	7	2.6	30
Jewel Cave NM	1	0	1	1	0	0	0.065	8	3.3	20
Jedediah Smith WA	1	0	2	1	1	0	0.067	12	4.1	60
Lee Metcalf WA, Taylor-Hilgard Unit[1, 2]	1	0	15	7	2	0	**0.117**	30	5.2	**290**
Lee Metcalf WA, Monument Mountains Unit[1, 2]	1	0	13	7	1	0	**0.094**	27	5.3	**290**
Lee Metcalf WA, Spanish Peaks Unit[1, 2]	0	0	9	6	1	0	**0.082**	20	4.4	**250**
Mount Naomi WA	5	1	1	1	0	0	0.072	11	4.7	30
Mount Rushmore National Memorial	1	0	0	0	0	0	0.065	8	3.2	20
Popo Agie WA	0	0	8	3	1	0	0.067	10	2.9	80
Sarvis Creek WA	1	0	1	1	0	0	0.066	7	2.9	30
Soldier Creek WA	1	0	0	0	0	0	0.062	8	3.4	20
Teton WA	0	0	4	2	1	0	0.068	12	3.6	70
Wellsville Mountain WA	5	1	1	1	0	0	0.075	12	5.6	40
Wind River IR	1	0	14	5	1	0	**0.133**	11	3.3	**180**

Note: Model-predicted concentrations that exceed the NAAQS are shown in **bold** text. For $PM_{2.5}$, ***bold and italic*** text indicates a modeled impact above the secondary $PM_{2.5}$ NAAQS.

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

[2] Maximum impacts of CO, ozone, and PM can be attributed to wildfires in 2008 that were included in the fire emissions inventory used to model future year conditions.

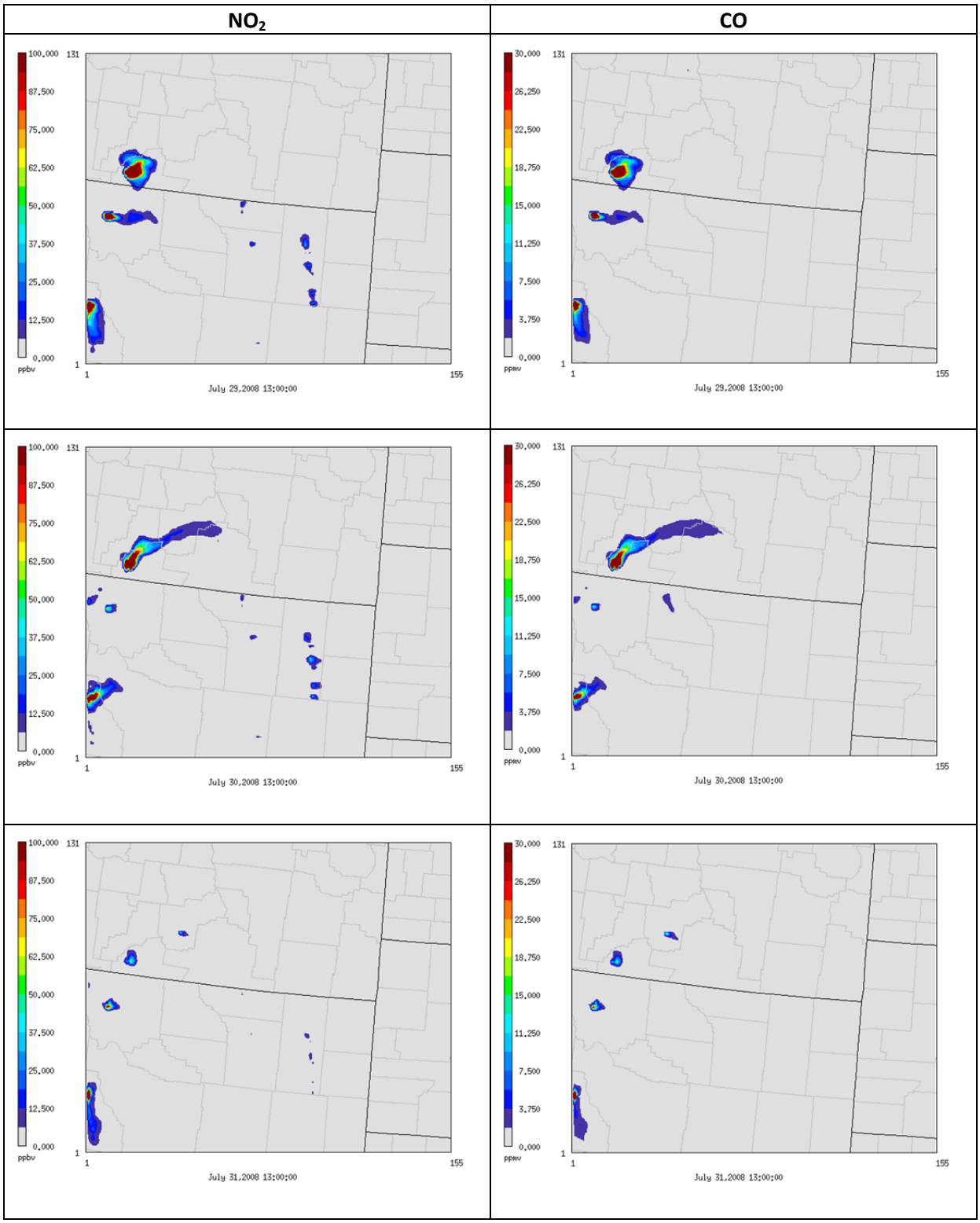

Figure 3-4 Year 2030 Model-predicted Hourly Average NO_2 and CO from July 29 through July 31

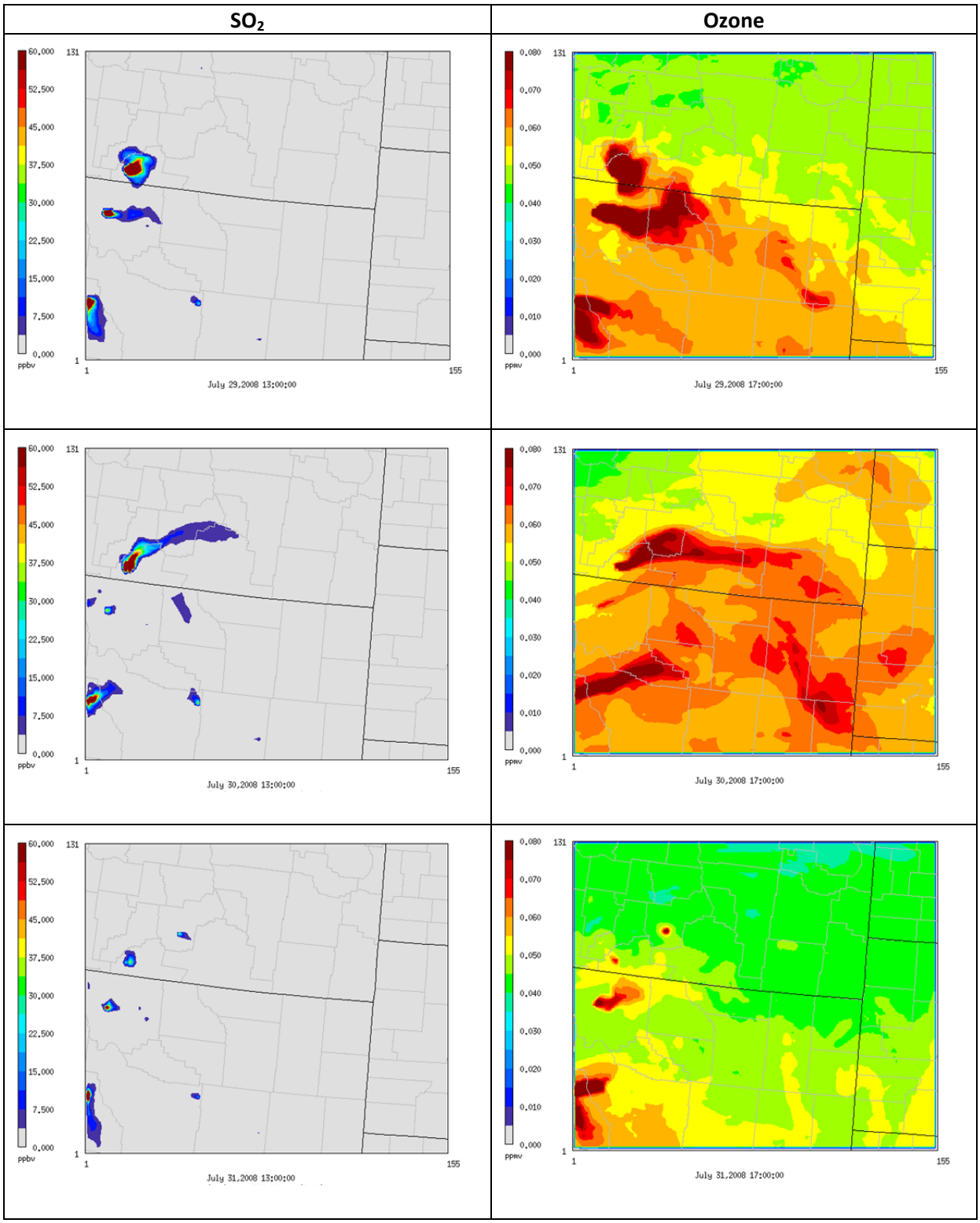

Figure 3-5 Year 2030 Model-predicted Hourly Average SO_2 and Ozone from July 29 through July 31

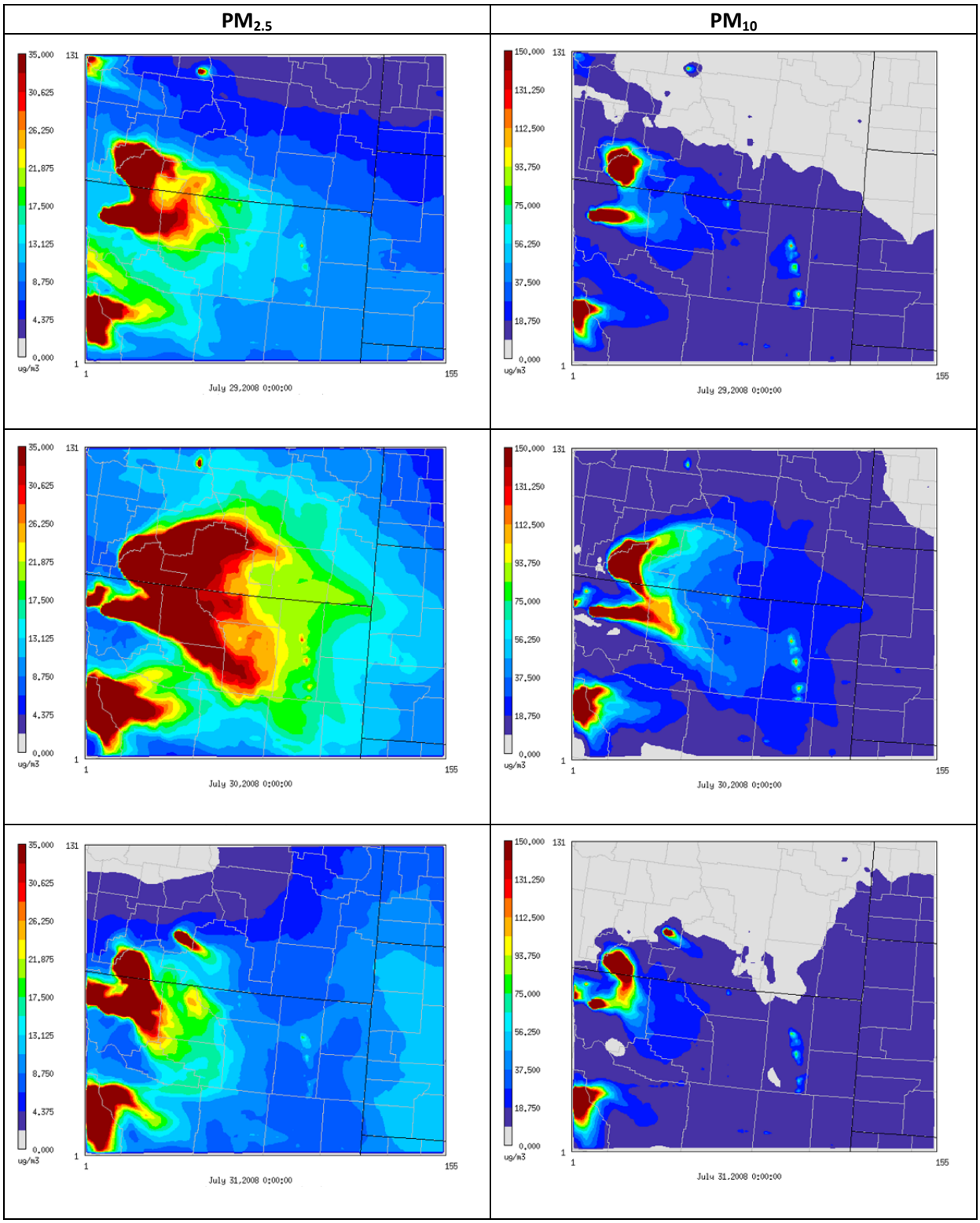

Figure 3-6 Year 2030 Model-predicted Daily Average $PM_{2.5}$ and PM_{10} and from July 29 through July 31

Table 3-7 Changes in Modeled Concentrations for Class I and Sensitive Class II Assessment Areas from 2008 to 2030

Assessment Area	NO_2 (ppb)	SO_2 (ppb)	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)
	Annual	3-hour	24-hour	Annual	24-hour
Class I Areas					
Badlands NP	-0.1	0.0	-0.5	-0.2	0.0
Badlands WA	-0.1	0.0	-0.5	-0.2	0.0
Bob Marshall WA, Flathead NF[1]	-0.1	0.0	-0.2	-0.1	-0.1
Bob Marshall WA, Lolo NF[1]	-0.1	0.0	-0.3	-0.1	-0.3
Bob Marshall WA, Lewis and Clark NF[1]	-0.1	0.0	-0.2	-0.1	0.0
Bridger WA	-0.1	0.0	0.0	-0.2	-0.6
Fitzpatrick WA	-0.1	0.0	-0.2	-0.1	-0.8
Fort Peck IR	-0.2	0.0	-0.4	-0.2	-0.3
Gates of the Mountains WA	-0.2	0.0	-0.2	-0.2	-0.4
Grand Teton NP	-0.2	0.0	-0.1	-0.3	-1.4
Lostwood WA	-0.2	0.0	-0.7	-0.3	-0.7
Medicine Lake WA	-0.2	0.1	-0.6	-0.3	0.0
Mount Zirkel WA	-0.2	0.0	-0.4	-0.2	-0.1
North Absaroka WA	-0.1	0.0	-0.3	-0.2	-0.7
Northern Cheyenne IR	-0.2	0.0	0.0	-0.1	-0.2
Rawah WA	-0.1	-0.1	-0.3	-0.2	-0.3
Red Rock Lakes WA	-0.1	0.0	-1.6	-0.4	-1.3
Rocky Mountain NP	-0.5	0.0	-0.4	-0.3	-1.3
Scapegoat WA	-0.1	0.0	-0.3	-0.1	-0.3
Theodore Roosevelt NP	-0.1	-0.1	-0.5	-0.2	-0.3
UL Bend WA	-0.1	0.0	-0.1	-0.1	0.0
Washakie WA	-0.1	0.0	-0.1	-0.2	-0.3
Wind Cave NP	-0.2	0.0	-0.1	-0.2	-0.1
Yellowstone NP	-0.2	0.0	-0.1	-0.3	-0.3
Class II Areas					
Absaroka-Beartooth WA, Gallatin NF[1]	-0.1	0.0	-0.1	-0.2	-0.1
Absaroka-Beartooth WA, Custer NF[1]	-0.1	0.0	-0.1	-0.1	-0.3
Agate Fossil Beds NM	-0.3	-0.1	-0.3	-0.4	-0.1
Bighorn Canyon National Recreation Area	-0.1	0.1	-0.1	-0.1	-0.4
Black Elk WA	-0.2	-0.1	-0.1	-0.1	0.6
Cloud Peak WA	-0.1	0.0	-0.1	-0.1	-0.5
Crow IR	-0.2	0.4	-0.1	-0.1	0.0
Devil's Tower NM	-0.2	0.1	-0.1	-0.2	1.1
Dinosaur NM	-0.2	0.0	-0.3	-0.5	-0.7
Fort Belknap IR	-0.1	0.0	-0.1	-0.2	0.1
Fort Laramie National Historic Site	-0.9	0.0	-0.5	-0.5	-0.6
High Uintas WA, Ashley NF[1]	-0.2	-0.3	-0.3	-0.3	-0.2

Table 3-7 Changes in Modeled Concentrations for Class I and Sensitive Class II Assessment Areas from 2008 to 2030

Assessment Area	NO_2 (ppb)	SO_2 (ppb)	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)
	Annual	3-hour	24-hour	Annual	24-hour
High Uintas WA, Wasatch NF[1]	-0.2	0.0	-0.3	-0.3	-0.2
Jewel Cave NM	-0.2	0.0	-0.1	-0.1	-0.1
Jedediah Smith WA	-0.2	0.0	-0.2	-0.3	-0.2
Lee Metcalf WA, Taylor-Hilgard Unit[1]	-0.1	0.0	-0.2	-0.2	-0.9
Lee Metcalf WA, Monument Mountains Unit[1]	-0.2	0.0	-0.1	-0.3	-0.9
Lee Metcalf WA, Spanish Peaks Unit[1]	-0.2	0.0	-0.6	-0.2	-0.1
Mount Naomi WA	-2.4	0.0	-1.6	-1.1	-2.2
Mount Rushmore National Memorial	-0.2	0.0	-0.1	-0.1	0.6
Popo Agie WA	-0.1	0.4	-0.3	-0.2	-0.4
Sarvis Creek WA	-0.2	0.0	-0.3	-0.2	-0.6
Soldier Creek WA	-0.2	-0.1	-0.1	-0.3	-0.1
Teton WA	-0.1	0.0	-0.1	-0.3	-0.2
Wellsville Mountain WA	-3.0	-0.3	-4.2	-1.8	-1.8
Wind River IR	-0.2	0.4	-0.1	-0.2	-0.8

Note: No model-predicted concentration changes exceeded PSD increments.

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

Table 3-8 MATS 8-hour Ozone Design Values for Base Year 2008 and Future Year 2030 at Monitoring Sites

Monitoring Site	Monitoring Site ID	Latitude (degrees)	Longitude (degrees)	Ozone Design Value (ppm)	
				2008	2030
Badlands NP, Jackson County, South Dakota	460711001	43.7469	-101.9411	0.068	0.060
Bismarck Residential, Burleigh County, North Dakota	380150003	46.8254	-100.7682	0.057	0.051
Boulder, Sublette County, Wyoming	560350099	42.7190	-109.7530	**0.079**	0.071
Brigham City, Box Elder County, Utah	490030003	41.4928	-112.0181	0.075	0.059
Daniel South, Sublette County, Wyoming	560350100	42.7907	-110.0551	0.069	0.062
Dunn Center, Dunn County, North Dakota	380250003	47.3132	-102.5273	0.057	0.053
Elementary School, Meade County, South Dakota	460930001	44.1556	-103.3158	0.056	0.050
Fargo, Mercer County, North Dakota	380570004	47.2986	-101.7669	0.060	0.056
Fort Collins, Larimer County, Colorado	80691004	40.5775	-105.0789	0.070	0.057
Fort Collins West, Larimer County, Colorado	80690011	40.5925	-105.1411	**0.080**	0.064
Hannover, Oliver County, North Dakota	380650002	47.1858	-101.4281	0.059	0.054
Herriman, Salt Lake County, Utah	490353008	40.5179	-112.0231	**0.080**	0.066
Highland, Utah County, Utah	490495008	40.4303	-111.8039	0.075	0.064
Jonah, Sublette County, Wyoming	560350098	42.4365	-109.6959	0.070	0.060
Lakepoint, Salt Lake County, Utah	490352004	40.7364	-112.2103	**0.079**	0.064

Table 3-8 MATS 8-hour Ozone Design Values for Base Year 2008 and Future Year 2030 at Monitoring Sites

Monitoring Site	Monitoring Site ID	Latitude (degrees)	Longitude (degrees)	Ozone Design Value (ppm)	
				2008	2030
Logan, Cache County, Utah	490050004	41.7311	-111.8375	0.070	0.056
Lostwood WA, Burke County, North Dakota	380130004	48.6419	-102.4018	0.058	0.054
Murphy Ridge, Uinta County, Wyoming	560410101	41.3731	-111.0424	0.064	0.052
North Provo, Utah County, Utah	490490002	40.2536	-111.6631	0.073	0.059
North Salt Lake City, Davis County, Utah	490110004	40.9030	-111.8845	**0.080**	0.066
Ogden, Weber County, Utah	490571003	41.3037	-111.9871	**0.079**	0.064
Overlook, McKenzie County, North Dakota	380530002	47.5812	-103.2995	0.062	0.057
Portage, Box Elder County, Utah	490037001	41.9460	-112.2332	0.074	0.059
Rocky Mountain NP, Larimer County, Colorado	80690007	40.2772	-105.5450	0.075	0.061
Salt Lake City, Salt Lake County, Utah	490353006	40.7364	-111.8722	**0.078**	0.064
Salt Lake City, Salt Lake County, Utah	490350003	40.6467	-111.8497	**0.080**	0.069
South Campbell County, Campbell County, Wyoming	560050456	44.1470	-105.5300	0.066	0.060
Spanish Fork, Utah County, Utah	490495010	40.1364	-111.6597	0.075	0.060
Theodore Roosevelt NP, Billings County, North Dakota	380070002	46.8943	-103.3785	0.062	0.057
Thunder Basin, Campbell County, Wyoming	560050123	44.6522	-105.2903	0.070	0.065
Tooele, Tooele County, Utah	490450003	40.5434	-112.2988	0.075	0.061
Wamsutter, Sweetwater County, Wyoming	560370200	41.6775	-108.0246	0.064	0.052
Washington Terrace, Weber County, Utah	490570007	41.1797	-111.9831	**0.081**	0.067
Weld County Tower, Weld County, Colorado	81230009	40.3864	-104.7374	0.075	0.062
West Valley City, Salt Lake County, Utah	490353007	40.7044	-111.9686	**0.081**	0.066
Wind Cave NP, Custer County, South Dakota	460330132	43.5578	-103.4839	0.066	0.060
Yellowstone NP, Teton County, Wyoming	560391011	44.5653	-110.4000	0.064	0.060
Yellowstone NP, Yellowstone County, Montana	301110086	45.9426	-108.3510	0.059	0.053

Note: **Bold** text indicates values that exceed the 8-hour ozone NAAQS.

3.3.3 Source Contributions to Cumulative Air Quality Impacts

The analyses of the model predicted cumulative air quality impacts for the 2020 and 2030 upper development scenarios show an overall improvement in ambient air quality in both 2020 and 2030 compared to base year 2008. Only the upper development scenario was modeled. Model-predicted future improvement to ambient air quality concentrations between the base year (2008) and the future years could be greater if actual coal mine development is less than the upper development scenario. As described in the Task 1A Report, modeled CO, ozone, and PM_{10} exceedences at Class I and sensitive Class II areas were primarily a result of the wildfires in the 2008 emissions inventory, which also was used for future year modeling. Other emissions sources also contribute to predicted changes in air quality concentrations between base year 2008 and each of the future years (2020 and 2030).

Mines are the third highest source of PM_{10} and $PM_{2.5}$ emissions within the 4-km modeling domain, behind wildfires and fugitive dust. Since production from coal mines and some other mines is projected

to increase by 2020 and 2030 relative to base year 2008, the contribution to PM_{10} concentrations also would likely increase within the PRB study area. Similarly, conventional oil and gas and CBNG development is the third highest source of TOG emissions within the 4-km modeling domain, behind biogenic emissions and wildfires. Since conventional oil and gas and CBNG production are projected to decrease by 2020 and 2030 relative to base year 2008, the contribution to ozone nearby and downwind of the PRB study area is likely to decrease. Coal-fired power plants are the highest source of SO_2 emissions within the 4-km domain. SO_2 emissions related to power plants within the PRB study area are projected to increase in 2020 and 2030 as new coal-fired power plants are projected to be permitted and built. As a result, the model-predicted SO_2 impacts increase in 2020 and 2030 when compared to the base year 2008 values for some areas nearby or downwind of the PRB study area. Power plants, mobile sources, conventional oil and gas, and CBNG sources similarly contribute to NO_2 impacts.

Model predicted cumulative air quality impacts remain unchanged or tend to show improvement between 2020 and 2030. Based on the model results, emissions of NO_x, TOG, CO, $PM_{2.5}$, and NH_3 all would decrease between 2020 and 2030, while emissions of SO_2 and PM_{10} would increase between 2020 and 2030 in the 4-km domain. Declining conventional oil and gas and CBNG production, mobile sources, and railroad emissions would contribute to the decrease in NO_2 impacts between 2020 and 2030. Because conventional oil and gas and CBNG production are projected to decrease between 2020 and 2030, the contribution to ozone nearby and downwind of the PRB study area likely would decrease. Though production from coal mines and some other mines are projected to increase between 2020 and 2030, there would be little change in PM_{10} impacts. Similarly, the additional coal-fired power plant projected to begin operation between 2020 and 2030 would result in almost no changes to SO_2 impacts in 2030 since the proposed location of the power plant would be downwind from the assessment areas. Regardless of the changes to the source sectors that would contribute to cumulative air quality impacts, the model-predicted concentrations for future years 2020 and 2030 do not exceed the NAAQS or state AAQS at almost all Class I and sensitive Class II assessment areas.

3.4 Cumulative Impacts on Visibility

Estimated visibility impacts at the Class I areas and sensitive Class II areas are presented both in terms of the total light extinction (Mm^{-1}) and deciviews for the 20 percent best days and 20 percent worst days in 2020 and 2030. Impacts also are shown for base year 2008 for comparison.

Visibility impacts are presented using two different methods. The first method presents the estimated visibility impacts based on the modeled concentrations of key pollutants. For the second method, the MATS tool was used to adjust modeled values based on observed values to account for model bias. In general, based on the Air Quality MPE (AECOM 2013a) conducted for the base year (2008), the modeled visibility impacts showed good agreement with monitoring data. Although the model-predicted maximum visibility impacts did not always occur at the same time or location as monitored events, the model-predicted maximum visibility impact frequently was similar in magnitude. Therefore, the future year (2020 and 2030) visibility impacts are likely to be similar to the impacts presented in this report.

3.4.1 2020 Upper Development Scenario

Table 3-9 presents the modeled visibility impacts for the 20th percentile best and 20th percentile worst visibility days for both base year 2008 and future year 2020. Based on the modeled data, the predicted 2020 visibility impacts are reduced or remain unchanged relative to base year 2008 for both the 20th percentile best and the 20th percentile worst days for all Class I assessment areas and most sensitive Class II assessment areas, with some exceptions. Notably, visibility impacts at Class II Crow IR, which is near the PRB study area, are predicted to be higher in 2020 than in base year 2008.

Areas with the predicted best visibility during the 20th percentile best days in 2020 are the Class I Mount Zirkel WA and the Class II Cloud Peak WA and High Uintas WA, Ashley NF, with extinction values ranging from 14.2 to 14.5 Mm^{-1} (3.5 to 3.7 dv). The areas with the predicted worst visibility conditions during the 20th percentile worst days in 2020 are the Class I Lostwood WA and Medicine Lake WA with

extinction values of 47.4 Mm^{-1} (15.6 dv) and 46.4 Mm^{-1} (15.3 dv), respectively. For assessment areas near the PRB study area, predicted highest visibility impacts on the 20th percentile worst days are 32.7 Mm^{-1} (11.8 dv) at the Northern Cheyenne IR (Class I) and 32.1 Mm^{-1} (11.7 dv) at the Crow IR (Class II). Assessment areas located downwind from the PRB study area and with the largest potential to be impacted by energy-related development have predicted visibility impacts on the 20th percentile worst days that are lower than those nearby the PRB study area. For example, the Class II Jewel Cave NM and Mount Rushmore National Memorial have extinction values of 30.5 Mm^{-1} (11.1 dv) and 30.1 Mm^{-1} (11.0 dv), respectively.

Table 3-10 provides the MATS-estimated visibility impacts for both base year 2008 and future year 2020. Based on the MATS-estimated data, the predicted visibility impacts for 2020 are reduced or remain unchanged relative to base year 2008 for both the 20 percent best and the 20 percent worst days for all assessment areas. In particular, the areas with the predicted best visibility conditions during the 20 percent best days in 2020 are the Class I Mount Zirkel WA and Rawah WA and the Class II Dinosaur NM and Sarvis Creek WA, with extinction values ranging from 10.5 to 10.7 Mm^{-1} (0.6 to 0.7 dv). The areas with the predicted highest visibility impacts during the 20 percent worst days in 2020 would be Lostwood WA and Medicine Lake WA (both Class I areas) with extinction values of 67.0 Mm^{-1} (19.0 dv) and 59.5 Mm^{-1} (17.8 dv), respectively. For assessment areas near the PRB study area, the highest visibility impacts on the 20 percent worst days are 40.8 Mm^{-1} (14.0 dv) at the Class I Northern Cheyenne IR and 40.4 Mm^{-1} (14.0 dv) at the Class II Crow IR. Assessment areas located downwind from the PRB study area and with the largest potential to be impacted by energy-related development have predicted visibility impacts on the 20 percent worst days that are slightly higher than those near the PRB study area. For example, the Class II Jewel Cave NM and Mount Rushmore National Memorial have extinction values of 44.0 Mm^{-1} (14.8 dv) and 43.9 Mm^{-1} (14.8 dv), respectively.

The results of the visibility analysis indicate that visibility impacts at a majority of the assessment areas would be reduced in 2020 relative to base year 2008 conditions, regardless of the method used to estimate the impacts. Note that only the upper development scenario was modeled. Model-predicted future improvement to visibility impacts between the base year and 2020 could be greater if actual coal mine development is less than the upper development scenario. The best visibly conditions in 2020 would likely be at the Mount Zirkel WA, and the worst visibility conditions would likely be at Lostwood WA, both Class I areas. Near the PRB study area, the Northern Cheyenne IR (Class I) and Crow IR (Class II) have the predicted highest visibility impacts. However, conclusions are mixed regarding the projected impact of PRB energy-related development on visibility conditions at areas nearby and downwind of the PRB study area. For areas near the PRB study area, the MATS-estimated data suggest that PRB energy-related development would not affect visibility conditions (i.e., visibility impacts would decrease in 2020 relative to base year 2008). Although the modeled impacts at the Northern Cheyenne IR suggest a similar decrease in impacts for 2020, modeled impacts at the Crow IR increase in 2020 relative to base year 2008, suggesting that PRB energy-related activities would impact visibility conditions near the PRB study area, particularly at the Crow IR. Similarly for areas downwind of the PRB study area, the MATS-estimated data suggest that PRB energy-related development would not adversely impact visibility conditions downwind of the PRB study area (e.g., visibility impacts would decrease at the Class II Jewel Cave NM and Mount Rushmore National Memorial). The modeled impacts at Mount Rushmore National Memorial suggest a similar decrease in impacts for 2020, but the impacts would increase slightly at Jewel Cave NM, suggesting that energy-related development activities would adversely impact visibility conditions downwind of the PRB study area.

Table 3-9 Modeled 20th Percentile Best and Worst Visibility Values for Base Year 2008 and Future Year 2020

Assessment Areas	20th Percentile Best Visibility (dv)		20th Percentile Worst Visibility (dv)		20th Percentile Best Visibility (Mm^{-1})		20th Percentile Worst Visibility (Mm^{-1})	
	2008	2020	2008	2020	2008	2020	2008	2020
Class I Areas								
Badlands NP	7.8	7.5	13.6	12.9	21.9	21.3	38.9	36.5
Badlands WA	8.0	7.7	13.8	13.0	22.2	21.7	39.6	36.8
Bob Marshall WA, Flathead NF[1]	6.6	6.4	12.1	11.7	19.4	19.0	33.4	32.2
Bob Marshall WA, Lolo NF[1]	6.4	6.2	11.6	11.2	19.0	18.6	31.7	30.7
Bob Marshall WA, Lewis and Clark NF[1]	6.4	6.3	11.9	11.6	19.0	18.8	33.0	31.9
Bridger WA	4.7	4.2	10.0	9.3	16.0	15.3	27.1	25.4
Fitzpatrick WA	4.4	4.0	9.6	9.1	15.5	14.9	26.1	24.7
Fort Peck IR	8.7	8.4	15.2	14.6	23.9	23.2	45.6	43.1
Gates of the Mountains WA	6.2	5.9	11.8	11.3	18.6	18.0	32.6	30.9
Grand Teton NP	6.7	6.0	12.3	11.2	19.5	18.3	34.2	30.8
Lostwood WA	9.6	9.4	16.3	15.6	26.1	25.6	50.9	47.4
Medicine Lake WA	9.1	8.8	15.8	15.3	24.9	24.2	48.5	46.4
Mount Zirkel WA	4.2	3.5	8.6	8.0	15.2	14.2	23.7	22.3
North Absaroka WA	5.2	4.8	11.2	10.3	16.7	16.1	30.6	28.0
Northern Cheyenne IR	6.3	6.0	12.1	11.8	18.8	18.3	33.6	32.7
Rawah WA	4.7	4.1	9.1	8.5	15.9	15.1	24.7	23.3
Red Rock Lakes WA	6.4	6.0	13.6	12.0	18.9	18.2	38.9	33.1
Rocky Mountain NP	4.6	3.9	9.3	8.6	15.9	14.8	25.3	23.5
Scapegoat WA	6.5	6.3	11.6	11.3	19.1	18.8	32.0	30.9
Theodore Roosevelt NP	8.8	8.5	14.1	13.6	24.0	23.4	40.8	38.8
UL Bend WA	7.5	7.2	13.0	12.7	21.2	20.6	36.8	35.4
Washakie WA	4.8	4.4	10.3	9.6	16.2	15.6	27.9	26.2
Wind Cave NP	6.4	6.1	12.1	11.5	19.0	18.4	33.4	31.6
Yellowstone NP	5.9	5.4	12.1	10.9	18.1	17.2	33.5	29.7
Class II Areas								
Absaroka-Beartooth WA, Gallatin NF[1]	7.8	4.7	13.6	10.2	21.9	16.0	38.9	27.6
Absaroka-Beartooth WA, Custer NF[1]	8.0	4.1	13.8	9.8	22.2	15.1	39.6	26.6
Agate Fossil Beds NM	6.6	6.9	12.1	11.9	19.4	19.8	33.4	32.9
Bighorn Canyon National Recreation Area	6.4	5.2	11.6	11.3	19.0	16.9	31.7	30.8
Black Elk WA	6.4	5.9	11.9	11.1	19.0	18.1	33.0	30.3

Table 3-9 Modeled 20th Percentile Best and Worst Visibility Values for Base Year 2008 and Future Year 2020

Assessment Areas	20th Percentile Best Visibility (dv)		20th Percentile Worst Visibility (dv)		20th Percentile Best Visibility (Mm^{-1})		20th Percentile Worst Visibility (Mm^{-1})	
	2008	2020	2008	2020	2008	2020	2008	2020
Cloud Peak WA	4.7	3.7	10.0	9.4	16.0	14.5	27.1	25.7
Crow IR	4.4	5.6	9.6	11.7	15.5	17.4	26.1	32.1
Devil's Tower NM	8.7	6.5	15.2	11.3	23.9	19.1	45.6	31.1
Dinosaur NM	6.2	4.3	11.8	8.9	18.6	15.3	32.6	24.5
Fort Belknap IR	6.7	7.4	12.3	12.8	19.5	21.0	34.2	36.1
Fort Laramie National Historic Site	9.6	7.2	16.3	11.8	26.1	20.5	50.9	32.5
High Uintas WA, Ashley NF[1]	9.1	3.7	15.8	8.5	24.9	14.5	48.5	23.4
High Uintas WA, Wasatch NF[1]	4.2	3.9	8.6	8.6	15.2	14.8	23.7	23.6
Jewel Cave NM	5.2	6.1	11.2	11.1	16.7	18.4	30.6	30.5
Jedediah Smith WA	6.3	6.2	12.1	11.5	18.8	18.7	33.6	31.6
Lee Metcalf WA, Taylor-Hilgard Unit[1]	4.7	5.3	9.1	10.5	15.9	16.9	24.7	28.7
Lee Metcalf WA, Monument Mountains Unit[1]	6.4	5.3	13.6	10.6	18.9	17.0	38.9	29.0
Lee Metcalf WA, Spanish Peaks Unit[1]	4.6	4.9	9.3	10.1	15.9	16.3	25.3	27.4
Mount Naomi WA	6.5	8.0	11.6	13.3	19.1	22.3	32.0	37.8
Mount Rushmore National Memorial	8.8	5.8	14.1	11.0	24.0	17.8	40.8	30.1
Popo Agie WA	8.8	4.0	14.1	8.8	24.1	14.9	41.1	24.1
Sarvis Creek WA	7.5	3.9	13.0	8.3	21.2	14.7	36.8	23.0
Soldier Creek WA	4.8	6.5	10.3	11.7	16.2	19.2	27.9	32.1
Teton WA	6.4	5.3	12.1	10.6	19.0	17.0	33.4	28.8
Wellsville Mountain WA	5.9	9.1	12.1	14.8	18.1	24.8	33.5	44.1
Wind River IR	5.1	4.4	10.9	9.7	16.7	15.6	29.7	26.3

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

Table 3-10 MATS-estimated 20 Percent Best and Worst Visibility Values for Base Year 2008 and Future Year 2020

Assessment Area	20 Percent Best Visibility (dv)		20 Percent Worst Visibility (dv)		20 Percent Best Visibility (Mm^{-1})		20 Percent Worst Visibility (Mm^{-1})	
	2008	2020	2008	2020	2008	2020	2008	2020
Class I Areas								
Badlands NP	6.6	6.4	16.6	16.1	19.4	19.0	52.7	50.0
Badlands WA	6.6	6.4	16.6	16.1	19.4	19.0	52.7	50.0
Bob Marshall WA[1]	2.9	2.8	14.7	14.6	13.3	13.2	43.7	43.0
Bridger WA	1.4	1.2	10.6	10.4	11.5	11.3	28.8	28.2
Fitzpatrick WA	1.4	1.2	10.6	10.3	11.5	11.3	28.8	28.1
Fort Peck IR	6.2	6.1	17.9	17.3	18.6	18.5	59.8	56.6
Gates of the Mountains WA	1.1	1.0	11.2	10.8	11.1	11.0	30.6	29.6
Grand Teton NP	1.8	1.5	11.6	11.2	12.0	11.6	31.8	30.7
Lostwood WA	8.1	7.9	19.7	19.0	22.5	22.0	71.9	67.0
Medicine Lake WA	6.3	6.2	18.4	17.8	18.8	18.5	63.0	59.5
Mount Zirkel WA	1.0	0.6	9.4	9.0	11.0	10.6	25.5	24.5
North Absaroka WA	1.4	1.2	11.7	11.5	11.5	11.3	32.3	31.5
Northern Cheyenne IR	3.5	3.3	14.2	14.0	14.2	13.9	41.4	40.8
Rawah WA	1.0	0.7	9.4	9.0	11.0	10.7	25.5	24.5
Red Rock Lakes WA	1.8	1.6	11.6	11.3	12.0	11.7	31.8	31.0
Rocky Mountain NP	1.9	1.6	12.0	11.3	12.1	11.8	33.3	31.0
Scapegoat WA	2.9	2.8	14.7	14.6	13.3	13.2	43.7	42.9
Theodore Roosevelt NP	6.6	6.5	17.9	17.3	19.3	19.1	59.8	56.5
UL Bend WA	4.3	4.2	15.0	14.8	15.4	15.2	44.9	43.7
Washakie WA	1.8	1.6	11.6	11.2	12.0	11.7	31.8	30.8
Wind Cave NP	4.5	4.3	15.4	14.8	15.7	15.4	46.7	43.8
Yellowstone NP	1.8	1.5	11.6	11.3	12.0	11.7	31.8	31.1
Class II Areas								
Absaroka-Beartooth WA[1]	1.4	1.2	11.7	11.4	11.5	11.3	32.3	31.4
Agate Fossil Beds NM	4.5	4.2	15.4	14.7	15.7	15.2	46.7	43.4
Bighorn Canyon National Recreation Area	1.4	1.3	11.7	11.5	11.5	11.4	32.3	31.7
Black Elk WA	4.5	4.3	15.4	14.8	15.7	15.4	46.7	43.9

Table 3-10 MATS-estimated 20 Percent Best and Worst Visibility Values for Base Year 2008 and Future Year 2020

Assessment Area	20 Percent Best Visibility (dv)		20 Percent Worst Visibility (dv)		20 Percent Best Visibility (Mm^{-1})		20 Percent Worst Visibility (Mm^{-1})	
	2008	2020	2008	2020	2008	2020	2008	2020
Cloud Peak WA	1.2	1.2	11.4	11.1	11.3	11.2	31.1	30.5
Crow IR	3.5	3.3	14.2	14.0	14.2	14.0	41.4	40.4
Devil's Tower NM[2]	ND	ND	ND	ND	ND	ND	ND	ND
Dinosaur NM	1.0	0.8	9.4	9.1	11.0	10.5	25.5	24.8
Fort Belknap IR	4.3	4.2	15.0	14.8	15.4	15.2	44.9	43.8
Fort Laramie National Historic Site	4.5	4.1	15.4	14.4	15.7	15.1	46.7	42.4
High Uintas WA[1]	1.4	1.1	10.6	9.9	11.5	11.2	28.8	27.0
Jewel Cave NM	4.5	4.4	15.4	14.8	15.7	15.5	46.7	44.0
Jedediah Smith WA	1.8	1.5	11.6	11.2	12.0	11.7	31.8	30.8
Lee Metcalf WA[1]	1.8	1.6	11.6	11.2	12.0	11.7	31.8	30.8
Mount Naomi WA	1.4	1.1	10.6	10.0	11.5	11.1	28.8	27.2
Mount Rushmore National Memorial	4.5	4.3	15.4	14.8	15.7	15.4	46.7	43.9
Popo Agie WA	1.4	1.2	10.6	10.2	11.5	11.3	28.8	27.7
Sarvis Creek WA	1.0	0.7	9.4	8.9	11.0	10.7	25.5	24.4
Soldier Creek WA	4.5	4.3	15.4	14.8	15.7	15.4	46.7	43.7
Teton WA	1.8	1.5	11.6	11.2	12.0	11.7	31.8	30.7
Wellsville Mountain WA	1.4	1.0	10.6	9.8	11.5	11.1	28.8	26.7
Wind River IR	1.4	1.2	10.6	10.3	11.5	11.3	28.8	28.0

[1] Assessment area was not broken out by discrete locations as presented in **Table 3-7** because monitoring data was only available at one site.

[2] ND = No monitoring data available.

3.4.2 2030 Upper Development Scenario

Table 3-11 presents the modeled visibility impacts for the 20th percentile best and 20th percentile worst visibility days for both base year 2008 and future year 2030. Similar to the 2020 modeled data, the predicted 2030 visibility impacts are reduced or remain unchanged relative to base year 2008 for both the 20th percentile best and the 20th percentile worst days for all Class I assessment areas and most sensitive Class II assessment areas, with some exceptions. Notably, visibility impacts at the Class II Crow IR, which is near the PRB study area, are predicted to be higher in 2030 than in base year 2008. Only the upper development scenario was modeled for 2030; therefore, model-predicted future visibly impacts between the base year and 2030 could be lower if actual coal mine development is less than the upper development scenario.

Areas with the predicted best visibility during the 20th percentile best days in 2030 are the Class I Mount Zirkel WA and the Class II Cloud Peak WA and High Uintas WA, with extinction values ranging from 14.1 to 14.7 Mm^{-1} (3.5 to 3.8 dv). The areas with the predicted worst visibility conditions during the 20th percentile worst days in 2030 are Lostwood WA and Medicine Lake WA (both Class I areas) with extinction values of 47.2 Mm^{-1} (15.5 dv) and 45.4 Mm^{-1} (15.1 dv), respectively. For assessment areas near the PRB study area, the highest visibility impacts on the 20th percentile worst days are 32.5 Mm^{-1} (11.8 dv) at the Class I Northern Cheyenne IR and 32.0 Mm^{-1} (11.6 dv) at the Class II Crow IR. Assessment areas located downwind from the PRB study area and with the largest potential to be impacted by energy-related development have predicted visibility impacts on the 20th percentile worst days that are lower than those nearby the PRB study area. For example, the Class II Jewel Cave NM and Mount Rushmore National Memorial have extinction values of 30.4 Mm^{-1} (11.1 dv) and 29.9 Mm^{-1} (10.9 dv), respectively.

Table 3-12 provides the MATS-estimated visibility impacts for both base year 2008 and future year 2030. Similar to the MATS-estimated 2020 data, the predicted visibility impacts for 2030 are lower or remain unchanged relative to base year 2008 for both the 20 percent best and the 20 percent worst days for all assessment areas. In particular, the areas with the predicted best visibility conditions during the 20 percent best days in 2030 are the Class I Mount Zirkel WA and Rawah WA and the Class II Dinosaur NM and Sarvis Creek WA, with extinction values ranging from 10.4 to 10.7 Mm^{-1} (0.4 to 0.7 dv). The areas with the predicted worst visibility conditions during the 20 percent worst days in 2030 are Lostwood WA and Medicine Lake WA (both Class I areas) with extinction values of 66.2 Mm^{-1} (18.9 dv) and 58.8 Mm^{-1} (17.7 dv), respectively. For assessment areas near the PRB study area, the highest visibility impacts on the 20 percent worst days are 40.7 Mm^{-1} (14.0 dv) at the Class I Northern Cheyenne IR and 40.2 Mm^{-1} (13.9 dv) at the Class II Crow IR. Areas located downwind from the PRB study area and with the largest potential to be impacted by energy-related development have predicted visibility impacts on the 20 percent worst days that are higher than those near the PRB study area. For example, the Class II Jewel Cave NM and Mount Rushmore National Memorial have extinction values of 43.8 Mm^{-1} (14.8 dv) and 43.5 Mm^{-1} (14.7 dv), respectively.

The results of the visibility analysis for future year 2030 are similar to those for 2020, indicating that visibility impacts at a majority of the assessment areas would be reduced in 2030 relative to base year 2008 conditions, regardless of the method used to estimate the impacts. Additionally, the best visibility conditions in 2030 are likely to be at the Mount Zirkel WA and the worst visibility conditions are likely to be at Lostwood WA, both Class I areas. Near the PRB study area, the Northern Cheyenne IR (Class I) and Crow IR (Class II) have the highest predicted visibility impacts. However, conclusions are mixed regarding the projected impact of PRB energy-related development on visibility conditions at nearby areas and downwind of the PRB study area. For areas near the PRB study area, the MATS-estimated data suggest that PRB energy-related development would not affect visibility conditions (i.e., visibility impacts would decrease in 2030 relative to base year 2008). Although the modeled impacts at the Northern Cheyenne IR suggest a similar decrease in impacts for 2030, modeled impacts at the Crow IR increase in 2030 relative to base year 2008, suggesting that PRB energy-related activities would impact visibility conditions near the PRB study area, particularly at the Crow IR. Similarly, for areas downwind of the PRB study area, the MATS-estimated data suggest that PRB energy-related development would not

adversely impact visibility conditions downwind of the PRB study area (e.g., visibility impacts would decrease at the Class II Jewel Cave NM and Mount Rushmore National Memorial). The modeled impacts at Mount Rushmore National Memorial suggest a similar decrease in impacts for 2030, but the impacts would increases slightly at Jewel Cave NM (impacts for the 20th percent best visibility days would increase, but impacts for the 20th percentile worst visibility days would decrease slightly), suggesting that energy-related development activities may adversely impact visibility conditions downwind of the PRB study area.

3.4.3 Source Contribution to Visibility Impacts

The sources that contribute to different air quality compounds similarly contribute to visibility impacts (e.g., mines contribute to PM_{10} impacts while the powers plants contribute to SO_2 and its reaction products that affect visibility). Since mines and power plants within the PRB are projected to increase production and emissions affecting visibility, these source sectors would likely have a larger contribution to total light extinction in the future than in base year 2008. However, based on the analysis, the model predicted cumulative air quality impacts for both 2020 and 2030 show an overall improvement in ambient air quality compared to base year 2008 as discussed in Section 3.3.3. Similarly, an overall improvement would be expected between 2020 and 2030. Regardless of the changes to the source sectors that would contribute to cumulative air quality impacts, the model-predicted concentrations for future years 2020 and 2030 do not exceed the NAAQS or state AAQS at almost all assessment areas.

Table 3-11 Modeled 20th Percentile Best and Worst Visibility Values for Base Year 2008 and Future Year 2030

Assessment Areas	20th Percentile Best Visibility (dv)		20th Percentile Worst Visibility (dv)		20th Percentile Best Visibility (Mm^{-1})		20th Percentile Worst Visibility (Mm^{-1})	
	2008	2030	2008	2030	2008	2030	2008	2030
Class I Areas								
Badlands NP	7.8	7.5	13.6	12.8	21.9	21.2	38.9	35.9
Badlands WA	8.0	7.7	13.8	12.9	22.2	21.6	39.6	36.2
Bob Marshall WA, Flathead NF[1]	6.6	6.4	12.1	11.7	19.4	19.0	33.4	32.2
Bob Marshall WA, Lolo NF[1]	6.4	6.2	11.6	11.2	19.0	18.6	31.7	30.7
Bob Marshall WA, Lewis and Clark NF[1]	6.4	6.3	11.9	11.6	19.0	18.8	33.0	31.8
Bridger WA	4.7	4.2	10.0	9.3	16.0	15.2	27.1	25.3
Fitzpatrick WA	4.4	4.0	9.6	9.0	15.5	14.9	26.1	24.7
Fort Peck IR	8.7	8.4	15.2	14.5	23.9	23.2	45.6	42.6
Gates of the Mountains WA	6.2	5.8	11.8	11.3	18.6	17.9	32.6	30.8
Grand Teton NP	6.7	5.9	12.3	11.1	19.5	18.0	34.2	30.3
Lostwood WA	9.6	9.4	16.3	15.5	26.1	25.5	50.9	47.2
Medicine Lake WA	9.1	8.8	15.8	15.1	24.9	24.1	48.5	45.4
Mount Zirkel WA	4.2	3.5	8.6	8.0	15.2	14.1	23.7	22.2
North Absaroka WA	5.2	4.7	11.2	10.2	16.7	16.0	30.6	27.7
Northern Cheyenne IR	6.3	6.0	12.1	11.8	18.8	18.2	33.6	32.5
Rawah WA	4.7	4.1	9.1	8.4	15.9	15.0	24.7	23.2
Red Rock Lakes WA	6.4	5.9	13.6	11.7	18.9	18.0	38.9	32.3
Rocky Mountain NP	4.6	3.8	9.3	8.5	15.9	14.7	25.3	23.4
Scapegoat WA	6.5	6.3	11.6	11.3	19.1	18.8	32.0	30.9
Theodore Roosevelt NP	8.8	8.4	14.1	13.5	24.0	23.3	40.8	38.5
UL Bend WA	7.5	7.2	13.0	12.6	21.2	20.5	36.8	35.3
Washakie WA	4.8	4.4	10.3	9.5	16.2	15.5	27.9	26.0
Wind Cave NP	6.4	6.1	12.1	11.4	19.0	18.4	33.4	31.3
Yellowstone NP	5.9	5.3	12.1	10.7	18.1	17.1	33.5	29.1
Class II Areas								
Absaroka-Beartooth WA, Gallatin NF[1]	7.8	4.6	13.6	10.1	21.9	15.9	38.9	27.4
Absaroka-Beartooth WA, Custer NF[1]	8.0	4.1	13.8	9.7	22.2	15.0	39.6	26.4

Table 3-11 Modeled 20th Percentile Best and Worst Visibility Values for Base Year 2008 and Future Year 2030

Assessment Areas	20th Percentile Best Visibility (dv)		20th Percentile Worst Visibility (dv)		20th Percentile Best Visibility (Mm^{-1})		20th Percentile Worst Visibility (Mm^{-1})	
	2008	2030	2008	2030	2008	2030	2008	2030
Agate Fossil Beds NM	6.6	6.7	12.1	11.8	19.4	19.6	33.4	32.5
Bighorn Canyon National Recreation Area	6.4	5.2	11.6	11.2	19.0	16.8	31.7	30.7
Black Elk WA	6.4	5.9	11.9	11.0	19.0	18.1	33.0	30.1
Cloud Peak WA	4.7	3.7	10.0	9.4	16.0	14.4	27.1	25.6
Crow IR	4.4	5.5	9.6	11.6	15.5	17.4	26.1	32.0
Devil's Tower NM	8.7	6.4	15.2	11.3	23.9	19.0	45.6	31.1
Dinosaur NM	6.2	4.1	11.8	8.9	18.6	15.1	32.6	24.3
Fort Belknap IR	6.7	7.4	12.3	12.8	19.5	20.9	34.2	36.0
Fort Laramie National Historic Site	9.6	7.1	16.3	11.6	26.1	20.4	50.9	31.8
High Uintas WA, Ashley NF[1]	9.1	3.7	15.8	8.5	24.9	14.5	48.5	23.3
High Uintas WA, Wasatch NF[1]	4.2	3.8	8.6	8.5	15.2	14.7	23.7	23.5
Jewel Cave NM	5.2	6.1	11.2	11.1	16.7	18.4	30.6	30.4
Jedediah Smith WA	6.3	6.1	12.1	11.3	18.8	18.4	33.6	31.0
Lee Metcalf WA, Taylor-Hilgard Unit[1]	4.7	5.2	9.1	10.4	15.9	16.8	24.7	28.2
Lee Metcalf WA, Monument Mountains Unit[1]	6.4	5.2	13.6	10.5	18.9	16.9	38.9	28.5
Lee Metcalf WA, Spanish Peaks Unit[1]	4.6	4.8	9.3	10.0	15.9	16.2	25.3	27.2
Mount Naomi WA	6.5	7.7	11.6	12.7	19.1	21.7	32.0	35.7
Mount Rushmore National Memorial	8.8	5.8	14.1	10.9	24.0	17.8	40.8	29.9
Popo Agie WA	8.8	4.0	14.1	8.8	24.1	14.9	41.1	24.0
Sarvis Creek WA	7.5	3.8	13.0	8.2	21.2	14.6	36.8	22.8
Soldier Creek WA	4.8	6.5	10.3	11.6	16.2	19.1	27.9	31.8
Teton WA	6.4	5.2	12.1	10.4	19.0	16.8	33.4	28.4
Wellsville Mountain WA	5.9	8.8	12.1	14.1	18.1	24.2	33.5	41.1
Wind River IR	5.1	4.4	10.9	9.6	16.7	15.5	29.7	26.1

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

Table 3-12 MATS-estimated 20 Percent Best and Worst Visibility Values for Base Year 2008 and Future Year 2030

Assessment Areas	20 Percent Best Visibility (dv)		20 Percent Worst Visibility (dv)		20 Percent Best Visibility (Mm^{-1})		20 Percent Worst Visibility (Mm^{-1})	
	2008	2030	2008	2030	2008	2030	2008	2030
Class I Areas								
Badlands NP	6.6	6.4	16.6	16.0	19.4	18.9	52.7	49.8
Badlands WA	6.6	6.4	16.6	16.0	19.4	18.9	52.7	49.8
Bob Marshall WA[1]	2.9	2.8	14.7	14.6	13.3	13.2	43.7	43.0
Bridger WA	1.4	1.2	10.6	10.4	11.5	11.3	28.8	28.2
Fitzpatrick WA	1.4	1.2	10.6	10.3	11.5	11.3	28.8	28.1
Fort Peck IR	6.2	6.1	17.9	17.3	18.6	18.5	59.8	56.2
Gates of the Mountains WA	1.1	1.0	11.2	10.8	11.1	11.0	30.6	29.5
Grand Teton NP	1.8	1.5	11.6	11.2	12.0	11.6	31.8	30.6
Lostwood WA	8.1	7.8	19.7	18.9	22.5	21.9	71.8	66.2
Medicine Lake WA	6.3	6.2	18.4	17.7	18.8	18.5	63.0	58.8
Mount Zirkel WA	1.0	0.6	9.4	8.9	11.0	10.6	25.5	24.4
North Absaroka WA	1.4	1.2	11.7	11.4	11.5	11.3	32.3	31.4
Northern Cheyenne IR	3.5	3.3	14.2	14.0	14.2	13.9	41.4	40.7
Rawah WA	1.0	0.7	9.4	8.9	11.0	10.7	25.5	24.4
Red Rock Lakes WA	1.8	1.5	11.6	11.3	12.0	11.6	31.8	30.9
Rocky Mountain NP	1.9	1.6	12.0	11.2	12.1	11.8	33.3	30.7
Scapegoat WA	2.9	2.8	14.7	14.6	13.3	13.2	43.7	42.9
Theodore Roosevelt NP	6.6	6.4	17.9	17.2	19.3	19.1	59.8	56.0
UL Bend WA	4.3	4.2	15.0	14.7	15.4	15.2	44.9	43.6
Washakie WA	1.8	1.6	11.6	11.2	12.0	11.7	31.8	30.7
Wind Cave NP	4.5	4.3	15.4	14.7	15.7	15.4	46.7	43.4
Yellowstone NP	1.8	1.5	11.6	11.3	12.0	11.6	31.8	31.0
Class II Areas								
Absaroka-Beartooth WA[1]	1.4	1.2	11.7	11.4	11.5	11.3	32.3	31.2
Agate Fossil Beds NM	4.5	4.2	15.4	14.6	15.7	15.3	46.7	43.0
Bighorn Canyon National Recreation Area	1.4	1.3	11.7	11.5	11.5	11.4	32.3	31.6

Table 3-12 MATS-estimated 20 Percent Best and Worst Visibility Values for Base Year 2008 and Future Year 2030

Assessment Areas	20 Percent Best Visibility (dv)		20 Percent Worst Visibility (dv)		20 Percent Best Visibility (Mm^{-1})		20 Percent Worst Visibility (Mm^{-1})	
	2008	2030	2008	2030	2008	2030	2008	2030
Black Elk WA	4.5	4.3	15.4	14.7	15.7	15.4	46.7	43.6
Cloud Peak WA	1.2	1.2	11.4	11.1	11.3	11.2	31.1	30.4
Crow IR	3.5	3.3	14.2	13.9	14.2	13.9	41.4	40.2
Devil's Tower NM[2]	ND	ND	ND	ND	ND	ND	ND	ND
Dinosaur NM	1.0	0.4	9.4	9.0	11.0	10.4	25.5	24.6
Fort Belknap IR	4.3	4.2	15.0	14.8	15.4	15.2	44.9	43.7
Fort Laramie National Historic Site	4.5	4.1	15.4	14.3	15.7	15.1	46.7	41.8
High Uintas WA[1]	1.4	1.1	10.6	9.9	11.5	11.1	28.8	26.9
Jewel Cave NM	4.5	4.4	15.4	14.8	15.7	15.5	46.7	43.8
Jedediah Smith WA	1.8	1.5	11.6	11.2	12.0	11.6	31.8	30.6
Lee Metcalf WA[1]	1.8	1.5	11.6	11.2	12.0	11.7	31.8	30.6
Mount Naomi WA	1.4	1.0	10.6	9.9	11.5	11.1	28.8	26.9
Mount Rushmore National Memorial	4.5	4.3	15.4	14.7	15.7	15.4	46.7	43.5
Popo Agie WA	1.4	1.2	10.6	10.2	11.5	11.3	28.8	27.6
Sarvis Creek WA	1.0	0.7	9.4	8.9	11.0	10.7	25.5	24.4
Soldier Creek WA	4.5	4.3	15.4	14.7	15.7	15.4	46.7	43.4
Teton WA	1.8	1.5	11.6	11.2	12.0	11.6	31.8	30.6
Wellsville Mountain WA	1.4	1.0	10.6	9.7	11.5	11.0	28.8	26.5
Wind River IR	1.4	1.2	10.6	10.3	11.5	11.2	28.8	28.0

[1] Assessment area was not broken out by discrete locations as presented in **Table 3-9** because monitoring data was only available at one site.

[2] ND = No monitoring data available.

3.5 Impacts on Atmospheric Deposition

Terrestrial deposition was assessed for 2020 and 2030 at the Class I and sensitive Class II areas, while aquatic deposition was assessed for sensitive lakes. Future year impacts are shown relative to base year 2008 conditions. Only the upper development scenario was modeled. Model-predicted future improvement to terrestrial and aquatic deposition between the base year and the future years could be greater if actual coal mine development is less than the upper development scenario.

Based on the Air Quality MPE (AECOM 2013a) conducted for the base year (2008), the modeled wet deposition tended to over-predict deposition in the mountains and under-predict deposition in the plains. While wet deposition is only part of total deposition (which is the sum of wet and dry deposition), the actual future year (2020 and 2030) deposition impacts may be lower than what is projected in this report for the mountainous areas and higher than what is projected for areas in the plains.

3.5.1 Deposition

3.5.1.1 2020 Upper Development Scenario

Model-predicted total annual nitrogen and sulfur deposition for future year 2020 are provided in **Table 3-13**. The model results suggest that maximum annual deposition rates would be well below any level of concern for sulfur. Although the data indicate that 53 of the 58 areas analyzed may exceed the nitrogen deposition level of concern (Baron 2006), nitrogen deposition in all of the assessment areas is projected to decrease relative to the base year 2008 based on the model results. For the Class I areas, the highest modeled impacts would occur at the North Absaroka WA, with nitrogen deposition reaching 9.57 kg N/ha/yr, exceeding the nitrogen deposition level of concern. For the Class II areas, the highest modeled impacts would occur at the Mount Naomi WA, with nitrogen deposition of 6.61 kg N/ha/yr, although this area is projected to have the largest decrease in nitrogen deposition (-3.29 kg N/ha/yr) relative to base year 2008 values.

Generally, nitrogen deposition is higher than sulfur deposition for all assessment areas, given the nature of emissions in the PRB study area. Near the PRB study area, the modeled nitrogen deposition data for the Class I Northern Cheyenne IR (1.91 kg N/ha/yr) and for the Class II Crow IR and Cloud Peak WA (2.40 and 2.93 kg N/ha/yr, respectively) are above the level of concern.

Table 3-13 Modeled Total Annual Nitrogen and Sulfur Deposition for 2020

Assessment Area	Nitrogen (kg N/ha/yr)[2]		Sulfur (kg S/ha/yr)[2]	
	2020 Total Annual Deposition	Absolute Change from Base Year 2008	2020 Total Annual Deposition	Absolute Change from Base Year 2008
Class I Areas				
Badlands NP	**2.60**	-0.38	0.62	0.02
Badlands WA	**3.07**	-0.40	0.70	0.02
Bob Marshall WA, Flathead NF[1]	**1.88**	-0.32	1.06	-0.02
Bob Marshall WA, Lolo NF[1]	**1.63**	-0.28	0.66	-0.01
Bob Marshall WA, Lewis and Clark NF[1]	**1.63**	-0.29	0.63	-0.02
Bridger WA	**4.11**	-0.56	1.28	-0.01
Fitzpatrick WA	**4.05**	-0.54	1.47	0.01

Table 3-13 Modeled Total Annual Nitrogen and Sulfur Deposition for 2020

Assessment Area	Nitrogen (kg N/ha/yr)[2]		Sulfur (kg S/ha/yr)[2]	
	2020 Total Annual Deposition	Absolute Change from Base Year 2008	2020 Total Annual Deposition	Absolute Change from Base Year 2008
Fort Peck IR	**1.53**	-0.12	0.32	0.00
Gates of the Mountains WA	1.39	-0.22	0.35	-0.01
Grand Teton NP	**2.71**	-0.33	0.82	-0.07
Lostwood WA	**1.87**	-0.12	0.44	0.00
Medicine Lake WA	**1.52**	-0.11	0.30	0.00
Mount Zirkel WA	**1.90**	-0.60	0.84	-0.04
North Absaroka WA	**9.57**	-0.32	1.04	-0.07
Northern Cheyenne IR	**1.91**	-0.25	0.56	0.01
Rawah WA	**1.62**	-0.45	0.68	-0.03
Red Rock Lakes WA	**4.57**	-0.22	0.50	-0.05
Rocky Mountain NP	**1.76**	-0.54	0.76	-0.02
Scapegoat WA	**1.84**	-0.30	0.82	-0.02
Theodore Roosevelt NP	**2.47**	-0.25	0.59	0.00
UL Bend WA	1.31	-0.12	0.23	0.00
Washakie WA	**2.32**	-0.35	0.77	-0.04
Wind Cave NP	**2.57**	-0.43	0.62	0.01
Yellowstone NP	**2.96**	-0.33	0.79	-0.08
Class II Areas				
Absaroka-Beartooth WA, Gallatin NF[1]	**2.38**	-0.30	0.76	-0.04
Absaroka-Beartooth WA, Custer NF[1]	**4.46**	-0.30	0.91	-0.04
Agate Fossil Beds NM	**2.06**	-0.34	0.45	0.00
Bighorn Canyon National Recreation Area	**2.26**	-0.27	0.56	0.01
Black Elk WA	**2.81**	-0.48	0.79	0.01
Cloud Peak WA	**2.93**	-0.38	1.05	-0.02
Crow IR	**2.40**	-0.28	0.68	0.01
Devil's Tower NM	**1.61**	-0.25	0.51	0.02
Dinosaur NM	0.96	-0.52	0.24	-0.01
Fort Belknap IR	1.29	-0.11	0.31	0.00
Fort Laramie National Historic Site	**1.76**	-0.34	0.32	-0.01
High Uintas WA, Ashley NF[1]	**1.89**	-0.72	0.95	-0.03

Table 3-13 Modeled Total Annual Nitrogen and Sulfur Deposition for 2020

Assessment Area	Nitrogen (kg N/ha/yr)[2]		Sulfur (kg S/ha/yr)[2]	
	2020 Total Annual Deposition	Absolute Change from Base Year 2008	2020 Total Annual Deposition	Absolute Change from Base Year 2008
High Uintas WA, Wasatch NF[1]	**1.89**	-0.71	0.94	-0.03
Jewel Cave NM	**1.97**	-0.36	0.44	0.00
Jedediah Smith WA	**3.63**	-0.43	1.13	-0.11
Lee Metcalf WA, Taylor-Hilgard Unit[1]	**2.88**	-0.27	0.84	-0.05
Lee Metcalf WA, Monument Mountains Unit[1]	**3.25**	-0.31	0.90	-0.07
Lee Metcalf WA, Spanish Peaks Unit[1]	**2.49**	-0.29	0.91	-0.04
Mount Naomi WA	**6.61**	-3.29	0.81	-0.05
Mount Rushmore National Memorial	**3.04**	-0.53	0.95	0.01
Popo Agie WA	**2.86**	-0.70	1.45	-0.04
Sarvis Creek WA	1.31	-0.39	0.59	-0.03
Soldier Creek WA	**2.38**	-0.41	0.55	0.01
Teton WA	**2.63**	-0.38	0.95	-0.06
Wellsville Mountain WA	**3.46**	-2.43	0.38	-0.03
Wind River IR	**1.81**	-0.33	0.48	0.02
Sensitive Lakes				
Black Joe Lake, Bridger WA	**2.86**	-0.67	1.74	-0.05
Deep Lake, Bridger WA	**3.08**	-0.71	1.92	-0.05
Hobbs Lake, Bridger WA	**4.47**	-0.60	1.61	0.01
Ross Lake, Fitzpatrick WA	**2.86**	-0.47	1.40	-0.01
Upper Frozen Lake, Bridger WA	**3.46**	-0.83	1.92	-0.05
Emerald Lake, Cloud Peak WA	**2.94**	-0.39	1.15	-0.02
Florence Lake, Cloud Peak WA	**3.39**	-0.45	1.53	-0.03
Lower Saddlebag Lake, Popo Agie WA	**2.72**	-0.68	1.55	-0.04

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

[2] **Bold** text indicates modeled values that exceed the levels of concern (i.e., terrestrial nitrogen deposition threshold of 1.5 kg N/ha/yr [Baron 2006] and terrestrial sulfur deposition threshold of 5 kg S/ha/yr [Fox et al. 1989]).

3.5.1.2 2030 Upper Development Scenario

Model-predicted total annual nitrogen and sulfur deposition for future year 2030 are provided in **Table 3-14**. The model results for 2030 are similar to the results for 2020. The model results suggest that maximum annual deposition rates would be well below any level of concern for sulfur. Although the data indicate that 52 of the 58 areas analyzed would exceed the nitrogen deposition level of concern (Baron 2006), nitrogen deposition in all of the assessment areas is projected to decrease relative to the base year 2008 based on the model results. For the Class I areas, the highest modeled impacts would occur at the North Absaroka WA, with nitrogen deposition reaching 9.53 kg N/ha/yr, exceeding the level of concern of 1.5 kg N/ha/yr. For the Class II areas, the highest modeled impacts would occur at the Mount Naomi WA, with nitrogen deposition of 6.37 kg N/ha/yr, although this area has the largest decrease in nitrogen deposition (-3.54 kg N/ha/yr) relative to base year 2008 values.

Generally, nitrogen deposition is higher than sulfur deposition for all assessment areas, given the nature of emissions in the PRB study area. Near the PRB study area, the modeled nitrogen deposition data for the Class I Northern Cheyenne IR (1.86 kg N/ha/yr) and for the Class II Crow IR and Cloud Peak WA (2.35 and 2.88 kg N/ha/yr, respectively) are above the level of concern.

Table 3-14 Modeled Total Annual Nitrogen and Sulfur Deposition for 2030

Assessment Area	Nitrogen (kg N/ha/yr)[2]		Sulfur (kg S/ha/yr)[2]	
	2030 Total Annual Deposition	Absolute Change from Base Year 2008	2030 Total Annual Deposition	Absolute Change from Base Year 2008
Class I Areas				
Badlands NP	**2.54**	-0.44	0.62	0.02
Badlands WA	**3.00**	-0.47	0.70	0.02
Bob Marshall WA, Flathead NF[1]	**1.88**	-0.32	1.06	-0.02
Bob Marshall WA, Lolo NF[1]	**1.62**	-0.28	0.66	-0.01
Bob Marshall WA, Lewis and Clark NF[1]	**1.63**	-0.30	0.63	-0.02
Bridger WA	**4.05**	-0.62	1.28	-0.01
Fitzpatrick WA	**4.00**	-0.60	1.47	0.01
Fort Peck IR	**1.51**	-0.13	0.32	0.00
Gates of the Mountains WA	1.36	-0.24	0.35	-0.01
Grand Teton NP	**2.66**	-0.37	0.82	-0.07
Lostwood WA	**1.85**	-0.15	0.44	0.00
Medicine Lake WA	1.50	-0.12	0.30	0.00
Mount Zirkel WA	**1.82**	-0.69	0.84	-0.04
North Absaroka WA	**9.53**	-0.36	1.04	-0.07
Northern Cheyenne IR	**1.86**	-0.30	0.56	0.01
Rawah WA	**1.56**	-0.51	0.68	-0.03
Red Rock Lakes WA	**4.55**	-0.24	0.50	-0.05
Rocky Mountain NP	**1.66**	-0.64	0.76	-0.02

Table 3-14 Modeled Total Annual Nitrogen and Sulfur Deposition for 2030

Assessment Area	Nitrogen (kg N/ha/yr)[2]		Sulfur (kg S/ha/yr)[2]	
	2030 Total Annual Deposition	Absolute Change from Base Year 2008	2030 Total Annual Deposition	Absolute Change from Base Year 2008
Scapegoat WA	**1.83**	-0.30	0.82	-0.01
Theodore Roosevelt NP	**2.41**	-0.31	0.59	0.00
UL Bend WA	1.29	-0.14	0.23	0.00
Washakie WA	**2.28**	-0.39	0.77	-0.04
Wind Cave NP	**2.50**	-0.50	0.63	0.01
Yellowstone NP	**2.91**	-0.37	0.79	-0.08
Class II Areas				
Absaroka-Beartooth WA, Gallatin NF[1]	**2.34**	-0.33	0.76	-0.04
Absaroka-Beartooth WA, Custer NF[1]	**4.42**	-0.34	0.91	-0.04
Agate Fossil Beds NM	**2.01**	-0.39	0.45	0.01
Bighorn Canyon National Recreation Area	**2.22**	-0.31	0.56	0.01
Black Elk WA	**2.73**	-0.57	0.79	0.01
Cloud Peak WA	**2.88**	-0.42	1.05	-0.02
Crow IR	**2.35**	-0.33	0.68	0.01
Devil's Tower NM	**1.57**	-0.29	0.52	0.02
Dinosaur NM	0.86	-0.62	0.24	-0.01
Fort Belknap IR	1.28	-0.12	0.31	0.00
Fort Laramie National Historic Site	**1.70**	-0.40	0.32	-0.01
High Uintas WA, Ashley NF[1]	**1.81**	-0.80	0.95	-0.03
High Uintas WA, Wasatch NF[1]	**1.81**	-0.79	0.94	-0.03
Jewel Cave NM	**1.92**	-0.41	0.45	0.01
Jedediah Smith WA	**3.58**	-0.48	1.13	-0.11
Lee Metcalf WA, Taylor-Hilgard Unit[1]	**2.85**	-0.29	0.84	-0.05
Lee Metcalf WA, Monument Mountains Unit[1]	**3.21**	-0.35	0.90	-0.07
Lee Metcalf WA, Spanish Peaks Unit[1]	**2.46**	-0.32	0.91	-0.04
Mount Naomi WA	**6.37**	-3.54	0.82	-0.05
Mount Rushmore National Memorial	**2.95**	-0.62	0.95	0.02
Popo Agie WA	**2.78**	-0.77	1.45	-0.04
Sarvis Creek WA	1.26	-0.44	0.59	-0.03
Soldier Creek WA	**2.32**	-0.48	0.55	0.02

Table 3-14 Modeled Total Annual Nitrogen and Sulfur Deposition for 2030

Assessment Area	Nitrogen (kg N/ha/yr)[2]		Sulfur (kg S/ha/yr)[2]	
	2030 Total Annual Deposition	Absolute Change from Base Year 2008	2030 Total Annual Deposition	Absolute Change from Base Year 2008
Teton WA	**2.59**	-0.42	0.95	-0.06
Wellsville Mountain WA	**3.24**	-2.65	0.38	-0.03
Wind River IR	**1.76**	-0.38	0.48	0.02
Sensitive Lakes				
Black Joe Lake, Bridger WA	**2.80**	-0.73	1.74	-0.05
Deep Lake, Bridger WA	**3.00**	-0.79	1.92	-0.05
Hobbs Lake, Bridger WA	**4.41**	-0.67	1.61	0.01
Ross Lake, Fitzpatrick WA	**2.81**	-0.52	1.40	-0.01
Upper Frozen Lake, Bridger WA	**3.37**	-0.92	1.92	-0.05
Emerald Lake, Cloud Peak WA	**2.89**	-0.44	1.16	-0.02
Florence Lake, Cloud Peak WA	**3.34**	-0.51	1.54	-0.03
Lower Saddlebag Lake, Popo Agie WA	**2.64**	-0.76	1.55	-0.04

[1] Some sites have been further broken out to show impacts at spatially discrete locations.

[2] **Bold** text indicates modeled values that exceed the levels of concern (i.e., terrestrial nitrogen deposition threshold of 1.5 kg N/ha/yr [Baron 2006] and terrestrial sulfur deposition threshold of 5 kg S/ha/yr [Fox et al. 1989]).

3.5.2 Sensitive Lake Acid Neutralizing Capacity

The estimated change in the ANC of the sensitive lakes was based on the modeled nitrogen and sulfur deposition data presented in **Tables 3-11** and **3-12** for future years 2020 and 2030, respectively, combined with other lake-specific information.

3.5.2.1 2020 Upper Development Scenario

The estimated change in ANC in 2020 for each of the sensitive lakes included in this study is presented in **Table 3-15**. All of the analyzed lakes are projected to experience changes in ANC greater than current recommended levels of acceptable change. Both the deposition and the ANC are projected to be lower in 2020 than in base year 2008. The lake with the largest projected impact (i.e., Upper Frozen Lake, Bridger WA) shows a change in ANC values from background of 304.7 percent (40.2 µeq/L) in base year 2008 that decreases to 260.3 percent (34.3 µeq/L) by 2020, while the lake with the lowest projected impact (i.e., Emerald Lake, Cloud Peak WA) shows a change in ANC of 41.5 percent in base year 2008 that decreases to 37.6 percent by 2020.

Table 3-15 Modeled Impacts on ANC of Sensitive Lakes for 2020

Lake	Number of Samples[1]	Actual Watershed Area[1] (hectare)	Annual Precipitation[1] (meter)	Background ANC[1] (µeq/L)	Nitrogen Deposition[2]		Sulfur Deposition[2]		ANC change[2,3] (percent)
					(kg N/ha/yr)	(eq/m^2/yr)	(kg S/ha/yr)	(eq/m^2/yr)	
Black Joe Lake, Bridger WA	72	890	1.47	70.6	**2.86**	0.0205	1.74	0.0109	**45.0**
Deep Lake, Bridger WA	62	205	1.69	61.1	**3.08**	0.0220	1.92	0.0120	**49.1**
Hobbs Lake, Bridger WA	76	293	1.44	69.8	**4.47**	0.0319	1.61	0.0101	**62.3**
Ross Lake, Fitzpatrick WA	57	4,450	1.32	54.0	**2.86**	0.0204	1.40	0.0088	**61.2**
Upper Frozen Lake, Bridger WA	3	64.8	1.60	13.2	**3.46**	0.0247	1.92	0.0120	**260.3 (34.3 µeq/L)**
Emerald Lake, Cloud Peak WA	40	293	1.60	70.0	**2.94**	0.0210	1.15	0.0072	**37.6**
Florence Lake, Cloud Peak WA	42	417	1.77	34.4	**3.39**	0.0242	1.53	0.0096	**82.9**
Lower Saddlebag Lake, Popo Agie WA	58	155	1.44	55.6	**2.72**	0.0194	1.55	0.0097	**54.3**

Note: eq/m^2/yr = equivalence per square meter per year.

[1] Number of samples, actual watershed area, annual precipitation, and background ANC are assumed to remain constant from the base year (2008).

[2] For modeled nitrogen and sulfur deposition data, **bold** text indicates values that exceed the level of concern (i.e., terrestrial nitrogen deposition of 1.5 kg N/ha/yr [Baron 2006] and terrestrial sulfur deposition of 5 kg S/ha/yr [Fox et al. 1989]). For ANC percent change, **bold** text indicates values that exceed the limit of acceptable change (i.e., 10 percent for lakes with a background ANC greater than 25 µeq/L and 1 µeq/L for lakes with a background ANC less than or equal to 25 µeq/L [Haddow et al. 1998]).

[3] ANC change (percent) is calculated according to the U.S. Department of Agriculture (USDA) Forest Service's *Screening Methodology for Calculating ANC Change to High Elevation Lakes* (USFS 2000).

3.5.2.2 2030 Upper Development Scenario

The estimated change in ANC in 2030 for each of the sensitive lakes included in this study is presented in **Table 3-16**. All of the analyzed lakes are projected to experience changes in ANC greater than current recommended levels of acceptable change. Both the deposition and the ANC are projected to be lower in 2030 than in base year 2008. The lake with the largest projected impact (i.e., Upper Frozen Lake, Bridger WA) shows a change in ANC values from background of 304.7 percent (40.2 µeq/L) in base year 2008 that decreases to 255.7 percent (33.7 µeq/L) by 2030, while the lake with the lowest projected impact (i.e., Emerald Lake, Cloud Peak WA) shows a change in ANC of 41.5 percent in 2008 that decreases to 37.1 percent by 2030.

3.5.3 Source Contribution to Deposition Impacts

In general, all projected deposition impacts to terrestrial and aquatic ecosystems in 2020 and 2030 are lower than impacts in base year 2008. Changes in the emission sources of NO_2 and SO_2 within the PRB study area would contribute to the changes in the nitrogen and sulfur deposition. The largest contributor to all SO_2 impacts is power plants, with power plants, mobile sources, conventional oil and gas, and CBNG sources the largest contributors to NO_2 concentrations. In the 4-km modeling domain, NO_2 emissions are projected to decrease in the future years (2020 and 2030), while SO_2 emissions are projected to increase. Within the PRB study area, NO_2 emissions are greater than SO_2 emissions. Correspondingly, nitrogen deposition is higher than sulfur deposition. Therefore, the projected decreases in mobile sources and conventional oil and gas and CBNG development and production in the PRB study area correspondingly would result in decreases in nitrogen deposition.

Similarly, nitrogen deposition impacts would show a general improvement between 2020 and 2030. Declining conventional oil and gas and CBNG production, mobile sources, and railroad emissions would contribute to the decrease in NO_2 impacts between 2020 and 2030. Although SO_2 emissions are projected to increase between 2020 and 2030, due to an additional coal-fired power plant, sulfur deposition would have little change between 2020 and 2030 because the location of the new power plant would be downwind of the assessment areas.

Table 3-16 Modeled Impacts on ANC of Sensitive Lakes for 2030

Lake	Number of Samples[1]	Actual Watershed Area[1] (hectare)	Annual Precipitation[1] (meter)	Background ANC[1] (µeq/L)	Nitrogen Deposition[2]		Sulfur Deposition[2]		ANC change[2,3] (percent)
					(kg N/ha/yr)	(eq/m^2/yr)	(kg S/ha/yr)	(eq/m^2/yr)	
Black Joe Lake, Bridger WA	72	890	1.47	70.6	**2.80**	0.0200	1.74	0.0109	**44.3**
Deep Lake, Bridger WA	62	205	1.69	61.1	**3.00**	0.0214	1.92	0.0120	**48.4**
Hobbs Lake, Bridger WA	76	293	1.44	69.8	**4.41**	0.0315	1.61	0.0101	**61.6**
Ross Lake, Fitzpatrick WA	57	4450	1.32	54.0	**2.81**	0.0201	1.40	0.0088	**60.5**
Upper Frozen Lake, Bridger WA	3	64.8	1.60	13.2	**3.37**	0.0241	1.92	0.0120	**255.7 (33.7 µeq/L)**
Emerald Lake, Cloud Peak WA	40	293	1.60	70.0	**2.89**	0.0206	1.16	0.0072	**37.1**
Florence Lake, Cloud Peak WA	42	417	1.77	34.4	**3.34**	0.0238	1.54	0.0096	**82.0**
Lower Saddlebag Lake, Popo Agie WA	58	155	1.44	55.6	**2.64**	0.0189	1.55	0.0097	**53.3**

1 Number of samples, actual watershed area, annual precipitation, and background ANC are assumed to remain constant from the base year (2008).

2 For modeled nitrogen and sulfur deposition data, **bold** text indicates values that exceed the level of concern (i.e., terrestrial nitrogen deposition of 1.5 kg N/ha/yr [Baron 2006] and terrestrial sulfur deposition of 5 kg S/ha/yr [Fox et al. 1989]). For ANC percent change, **bold** text indicates values that exceed the limit of acceptable change (i.e., 10 percent for lakes with a background ANC greater than 25 µeq/L and 1 µeq/L for lakes with a background ANC less than or equal to 25 µeq/L [Haddow et al. 1998]).

3 ANC change (percent) is calculated according to the USDA Forest Service's *Screening Methodology for Calculating ANC Change to High Elevation Lakes* (USFS 2000).

3.6 Greenhouse Gas Emissions

GHG emissions were developed to provide an estimate of potential GHG emissions associated with future energy-related development in the PRB study area for future years 2020 and 2030 under both the lower and upper production scenarios. The GHG emissions for each source sector subsequently were converted into CO_{2eq} to provide an estimate of the associated total global warming potential. The estimated cumulative GHG emissions and associated CO_{2eq} for future years 2020 and 2030 are presented in **Tables 3-17** and **3-18**, respectively.

Currently there are no established thresholds for GHG emissions. However, the Council on Environmental Quality advises federal agencies to consider an analysis of the direct and indirect GHG emissions from proposed projects if a project would be reasonably anticipated to cause direct emissions of 25,000 metric tpy or more of CO_{2eq} GHG emissions. Agencies are advised to consider this an indicator that a quantitative and qualitative assessment may be meaningful to decision makers and the public. Evaluation of potential GHG emissions for future projects would be considered in the preparation of future project-specific NEPA analyses.

Table 3-17 Projected Annual GHG Emissions for the 2020 Upper and Lower Development Scenarios

Production Scenario	Source Sector	Projected Annual GHG Emissions				
		CO_2	CH_4	N_2O	CO_{2eq}	
		(tons)	(tons)	(tons)	(tons)	(tonnes)
Lower Production	Conventional Oil and Gas and CBNG Development and Production	386,576	36,005.8	4.70	1,096,637	1,016,454
	Coal Mining	3,949,216	214,446	31	8,462,157	7,676,818
	Power Plants	27,083,241	301	450	27,229,103	24,702,081
	Coal Transportation by Railroad to PRB Boundary	1,155,206	47	9	1,159,095	1,051,524
	Total Lower	**32,574,239**	**250,800**	**495**	**37,946,992**	**34,446,877**
Upper Production	Conventional Oil and Gas and CBNG Development and Production	386,576	36,005.8	4.70	1,096,637	1,016,454
	Coal Mining	4,831,148	262,335	38	10,351,911	9,391,192
	Power Plants	29,122,887	324	484	29,279,733	26,562,399
	Coal Transportation by Railroad to PRB Boundary	1,482,213	60	12	1,487,203	1,349,182
	Total Upper	**35,822,824**	**298,725**	**539**	**42,215,484**	**38,319,22**

Table 3-18 Projected Annual GHG Emissions for the 2030 Upper and Lower Development Scenarios

Production Scenario	Source Category	Projected Annual GHG Emissions				
		CO_2	CH_4	N_2O	CO_{2eq}	
		(tons)	(tons)	(tons)	(tons)	(tonnes)
Lower Production	Conventional Oil and Gas and CBNG Development and Production	242,791	31,745.5	3.45	862,541	793,769
	Coal Mining	4,124,512	223,964	32	8,837,771	8,017,573
	Power Plants	29,026,962	322	482	29,183,291	26,474,908
	Coal Transportation by Railroad to PRB Boundary	1,181,353	48	10	1,185,330	1,075,325
	Total Lower	34,575,618	256,080	527	40,068,933	36,361,575
Upper Production	Conventional Oil and Gas and CBNG Development and Production	242,791	31,745.5	3.45	862,541	793,769
	Coal Mining	5,859,550	318,178	46	12,555,510	11,390,284
	Power Plants	36,781,731	408	611	36,979,853	33,547,903
	Coal Transportation by Railroad to PRB Boundary	1,780,500	72	14	1,786,494	1,620,697
	Total Upper	44,664,572	350,404	674	52,184,398	47,352,653

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